

**Converter test kit OPTIMUS
for OPTIMUS 50/65/80 generators Release 3.x
with converters 4512 104 7231 1/2/3**

4512 104 91681

FILING INSTRUCTIONS

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SERVICE MANUAL

742

UNIT

**Converter test kit OPTIMUS
for OPTIMUS 50/65/80 generators Release 3.x
with converters 4512 104 7231 1/2/3**

4512 104 91681

DMC Hamburg

Printed in Hamburg, Germany

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SERVICE MANUAL - UNIT**Converter test kit OPTIMUS
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with converters 4512 104 7231 1/2/3**

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File: UNIT_ConvTestKit_22721_AB_BW.doc

List of pages and drawings (LOPAD)**Manual Order No: 4512 984 22721
released 11/2002**

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3...39 (02.0)

6-01 (b/02.0) OPTIMUS RF**6-1 ... 6-24 (b/02.0) OPTIMUS RF**

TEXT

Contents	5
1. Introduction	5
1.1. Scope of delivery	5
1.2. Tools	5
2. Generator condition after failure event	6
2.1. Special case	6
2.2. All other cases	6
2.3. Prerequisites before checking the generator	6
3. Check of generator mains supply parts	7
3.1. Condition(s) when the service comes to the site	8
3.1.1. ENF2 tripped, possibly in combination with ENF1 and? mains fuses	8
3.1.2. ENF1 tripped, possibly in combination with mains fuses	8
3.2. Check for open springs at damping resistors	9
3.3. Check for contacts that are welded at breakers and contactors	9
4. Converter checks (EQ frontal and E2Q rear)	10
4.1. Visual converter check	10
4.2. Measuring of converter parts	10
4.2.1. Rectifier check	10
4.2.2. IGBT check	11
4.2.3. Overvoltage diode check	12
4.2.4. Resistor check (PCB versions 4512 108 0862x / 0934x)	12
4.2.5. Power cable harness check	13
4.2.6. Resonance capacitor check	13
5. Check of the high voltage transformer	14
5.1. Analysis	15
6. Visual check of the X-ray tube	16
7. Interim results	16
8. Tube check with Rotor Control part 1	17
9. kV-driver test	17
10. Tube check with Rotor Control part 2	18
11. Tube and high-voltage cable test with high voltage	19

12. Measuring of primary currents 23

12.1. Measuring of the resonance frequency.....28

12.2. Measurement of kV behavior with an adapted tube.....29

12.3. Measuring of kV behavior with a non-adapted tube (Optimus 65/80) 30

13. Reconditioning of the tube(s) 31

14. Final system test.....33

APPENDIX

List of checked parts of generator 3x.....37

1. Introduction

With this document it should be possible to determine which part of kV units of an Optimus generator is still operational and which part is defective and has to be replaced.

1.1. Scope of delivery

- 2 current transformers
(ratio 1:1000, 20 Ω resistors at the secondary coil give a ratio of 50A primary / 1V secondary)
- Test cable with resistor
- Test cable with diode
- Unit Manual Converter R/F
- This documentation

1.2. Tools

- Standard tools
- Extension boards C (96-pin)
- Dual trace oscilloscope with:
 - 2 probes for signals
 - 1 probe for external triggering
- Multimeter with diode test option
- 1 battery 1.5V D cell (R20) preferred
C cell (R14) or AA cell (R6) possible

2. Generator condition after failure event

ENF1 and/or **ENF2** and/or **ENF3** tripped.

Mains fuses might have additionally tripped.

2.1. Special case

ENF3 tripped, possibly in combination with **ENF2** and? **ENF1** and? mains fuses:

Problem most likely caused by rotor control unit EY (high speed) or EYA (low speed).
Solutions for rotor control problems are not part of this document.

2.2. All other cases

The generator has to be kept in this condition to discover the cause of the problem.

A non-qualified person (e.g. hospital technician not familiar with Optimus) should not be asked to just turn the fuses back on to prevent further damage.

A qualified person like a Philips field engineer (trained on Optimus) must visit the site.

2.3. Prerequisites before checking the generator

CAUTION!

Do not remove PCB kV-power from the IGBT transistors.
Electrostatic discharge and mobile phone waves can damage and destroy IGBTs when gate connections are open.



WARNING!

The generator must be switched OFF and must be completely cut from mains (e.g. room mains switch or earth leakage current breaker).

All following checks must be made without mains power.

3. Check of generator mains supply parts

- Measure DC voltage at auxiliary contacts 41-42 of ENK2.
(Converter DC discharging contact, max voltage can be 750VDC.)

If 0V is measured:

- the contact is closed (and the converter DC is discharged within 1 minute)
- or
- the contact is open and the converter DC is discharged and safe.



WARNING!

In case one of the ENK2 main contacts is welded the converter DC discharge time is much longer as the discharging auxiliary contact ENK2 41-42 cannot be closed.

600VDC discharge time to < 60VDC normally 40 seconds.
With open contact ≥ 11 minutes to be < 60VDC.

- Check if any main contact of contactor ENK2 is welded:

Mechanical check: If snap-on auxiliary contacts or auxiliary contact block cannot be removed from the main contactor at least one contact is welded.

ENK2	phase 1	1 - 2	contactor ENK2	2422 132 06621
	phase 2	3 - 4	+ 3 aux. contacts NO	2422 135 04355
	phase 3	5 - 6	+ 1 aux. contact NC	2422 135 04023
			or	
			successor contactor	2422 132 07381
			+ succ. aux. cont. block	2422 135 04464
			+ succ. R/C circuit	2422 135 04661

- Record the conditions on last page.
- If contacts have been found to be welded replace contactor, its auxiliary contacts or contact block + the R/C circuit.

3.1. Condition(s) when the service comes to the site

3.1.1. ENF2 tripped, possibly in combination with ENF1 and? mains fuses

Problem might be caused by any of the:

- internal generator units (Optimus RAD + R/F)
- or
- external units (Optimus RAD only) connected to breaker ENF2 :T1 :T2 :T3.

Solutions for such a case are not part of this document.

3.1.2. ENF1 tripped, possibly in combination with mains fuses

Problem most likely caused by kV unit malfunction (kV-control, kV-power, converter(s), HV transformer) or external parts e.g. HV cable(s) or tube.



- Open the cover of the frontal (and rear where present) converter.
- Measure DC at PCB kV-power EQ100 at E2 – C1 (at both converters, see layout drawings attached). The measured DC must be < 10VDC.

3.2. Check for open springs at damping resistors

EN :R1 safety resistor 47Ω 100W 4512 100 45441
:R2
:R3

- Record the conditions on sheet of appendix.
- Check for open springs at damping resistors.
 Springs might be open if all breakers are ON when the service comes to the site.
 In this case the generator must have been switched ON after all fuses and breakers were reactivated. Short-circuit in the converter or its mains rectifier/filter could have happened.
 Springs can be resoldered. If the springs have to be resoldered, use as little solder as possible.
- Check that the ceramic resistor bodies do not have cracks. In case of cracks the springs must be resoldered.

3.3. Check for contacts that are welded at breakers and contactors

- Switch OFF breakers ENF1 and ENF2.

ENF1	L1 – T1	automatic circuit-breaker ENF1	Optimus 50	2422 129 15514
	L2 – T2		or successor	2422 129 16291
	L3 – T3			
			Optimus 65/80	2422 129 15513
			or successor	2422 129 16292

ENF2	L1 – T1	automatic circuit-breaker ENF2	Optimus 50/65/80	2412 129 00341
	L2 – T2		or successor	2422 129 16288
	L3 – T3			

ENK1	phase 1	2 – 1	contactor ENK1	Optimus 50	2422 132 06625
	phase 2	4 – 3		or successor	2422 132 07382
	phase 3	6 – 5		+ R/C circuit	2422 135 04662
			Optimus 65/80	2422 132 06624	
			or successor	2422 132 07383	
			+ R/C circuit	2422 135 04662	

- Record the conditions of the breakers in the appendix.
- Check for contacts that are welded at breakers and contactors.
 If contacts have been found to be welded replace breaker(s) and/or contactor(s).
- Remove the converter mains lines (frontal and rear converter) from contactor ENK1 :1 :3 :5.
 Measure with an ohmmeter each line against the others (of each converter).
 There should be no short-circuit, the meter should display 2MΩ ±5% after at least 20 seconds (filter resistors).

4. Converter checks (EQ frontal and E2Q rear)

4.1. Visual converter check

- Check the converter visually.
The entire converter chassis must be replaced if cracks are visible at the white IGBT body (looking through the converter cage grid) or if the kV-power PCB Q100 is bent towards the cover plate.

4.2. Measuring of converter parts

Use an ohmmeter which has a diode test feature.

- Check the polarity of the meter (for ohm and diode testing):

Anode of diode symbol on meter = positive voltage >> **PLUS** (see measurement)

Cathode of diode symbol on meter = negative voltage >> **MINUS** (tables)

Ω = Normal ohm measurements

$\rightarrow$ = Diode test option of meter

4.2.1. Rectifier check

- Open the right side of the converter(s) to get access to the mains rectifier.

L1 $\emptyset$	$\emptyset$ -
L2 $\emptyset$	$\emptyset$ -
L3 $\emptyset$	$\emptyset$ +

Rectifier EQV5 layout

MINUS	PLUS $\rightarrow$		PLUS	MINUS $\rightarrow$	
L1 / L2 / L3 $\emptyset$	$\emptyset$ -	$\emptyset$ +	L1 / L2 / L3 $\emptyset$	$\emptyset$ -	$\emptyset$ +
	450mV $\pm$ 10%	∞		∞	450mV $\pm$ 10%

- Record the conditions in the appendix.

4.2.2. IGBT checkLegend

typical values when part is OK
typical values of defective parts If at least one test fails the converter must be exchanged. Proceed with chapter 5.

The table below shows results of IGBT emitter - collector measurement.
 Converter working OK and completely assembled.
 Q100 kV-power PCB 4512 108 0862x / 0934x

MINUS	PLUS	Ω	→	PLUS	MINUS	Ω	→
E1 E2,3,4	C1 C2,3,4	21.5 - 22k Ω	∞	E1 E2,3,4	C1 C2,3,4	16.5k Ω $\pm$ 10%	300mV $\pm$ 10%
Ex	Cx	0 Ω	< 200mV	Ex	Cx	0 Ω	< 200mV

The table below shows values of IGBT gate - emitter resistances.
 Converter working OK and completely assembled.
 Q100 kV-power PCB 4512 108 0862x / 0934x

MINUS	PLUS	Ω	PLUS	MINUS	Ω
G1 G2,3,4	E1 E2,3,4	3.8k Ω $\pm$ 10%	G1 G2,3,4	E1 E2,3,4	4.2k Ω $\pm$ 10%
Gx	Ex	0 Ω	Gx	Ex	0 Ω

- Record the conditions in the appendix.

4.2.3. Overvoltage diode check

cathode = heat sink plate

MINUS	PLUS	→	PLUS	MINUS	→
cathode V500 V501,2,3	anode V500 V501,2,3	310mV ±10%	cathode V500 V501,2,3	anode V500 V501,2,3	∞
cathode V5xx	anode V5xx	0	cathode V5xx	anode V5xx	0

- Record the conditions in the appendix.

4.2.4. Resistor check (PCB versions 4512 108 0862x / 0934x)

- Check 2 groups of 3 parallel resistors:

R506 / 507 / 508

and

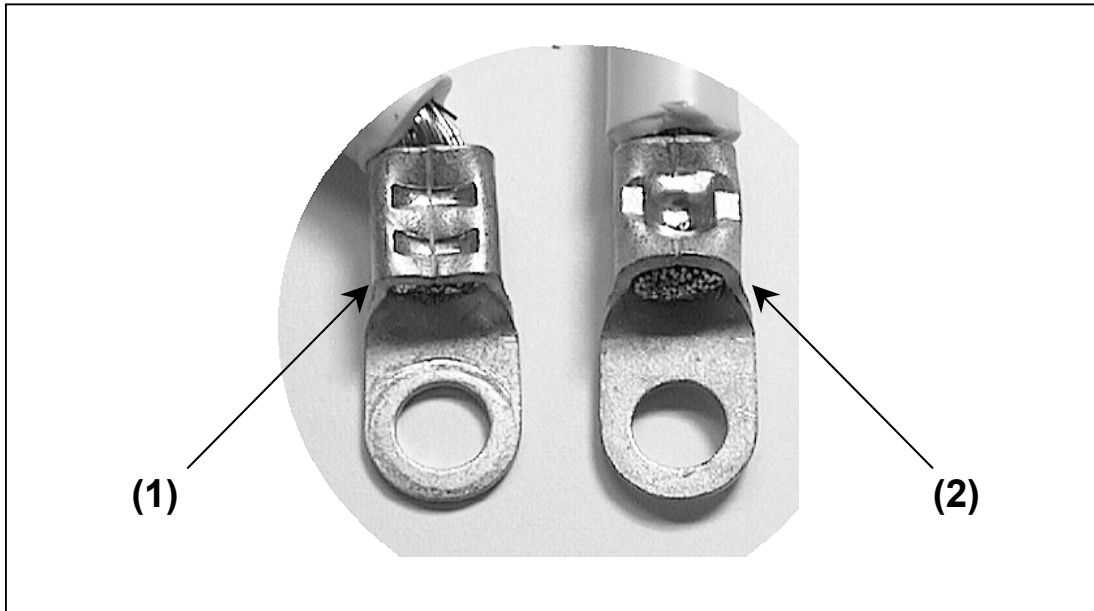
R509 / 510 / 511

With $39\Omega \pm 5\%$ per group. Each resistor must have a resistance of $13\Omega \pm 5\%$.

- Record the conditions in the appendix.

4.2.5. Power cable harness check

- Check internal converter power cable connections at resonance capacitors C3:2 and C13:2.
If the connectors look like (2) no additional action is necessary.
If one of the connectors looks like (1) and if signs of overheating are visible replace the converter.



- Record the conditions in the appendix.

4.2.6. Resonance capacitor check

- Remove primary lines from resonance capacitors C3:1 and C13:1 of frontal (and rear) converter.
- Check both capacitors for:
 - short-circuit
 - open connection

As it is not possible to measure the capacitance with an ohmmeter it is sufficient to see a variable resistance value for a certain time and finally a high resistance or open connection.
Once a high resistance or open connection is displayed reverse the measuring lines. If it comes again to an unstable resistance display with a high resistance or open connection display at the end, the capacitor should be OK.

If a capacitance measuring device is available it should display $8\mu\text{F} \pm 5\%$ (apart from the meter tolerance).

If a capacitor is defective (short or open) and no other part of the converter is defective which requires a converter unit exchange, replace the capacitor (2019 321 00016).

- Record the conditions in the appendix.

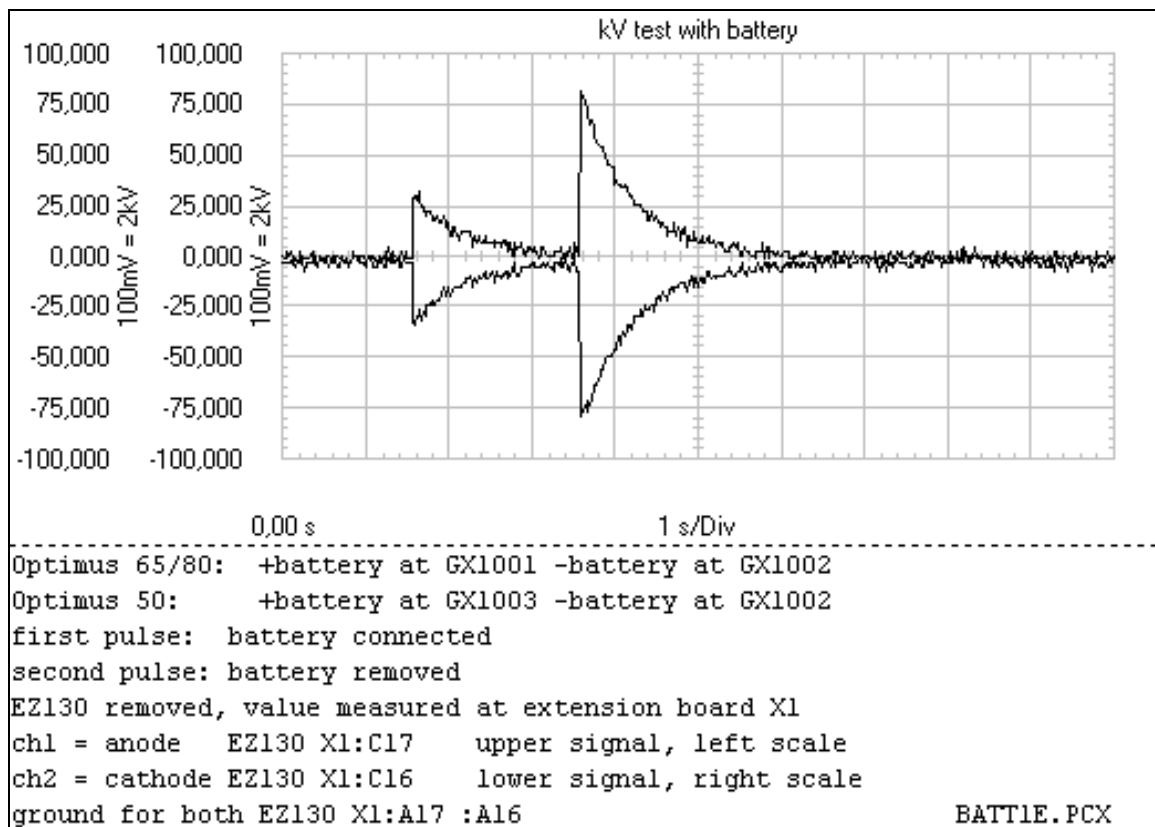
NOTE

Leave the primary lines disconnected from the capacitors for further tests.

5. Check of the high voltage transformer

- Remove PCB EZ130 kV-control.
- Insert extender PCB at EZ130 X1 (or use the backpanel connections, which is less convenient).
- Establish oscilloscope connections:
 - channel 1** = anode EZ130 X1:C17 10 or 20mV/div
 - channel 2** = cathode EZ130 X1:C16 10 or 20mV/div
 - ground** = EZ130 X1 :A17 :A16
 - trigger** = positive slope anode ch1 or negative slope cathode ch2
trigger level according to signal level
 - time base** = 500ms/div or 1s/div

Signal amplitudes might look different depending on the battery type, connection cables used and the "contact force" at the battery.



- Measure
 - (1) with high voltage cables and tube connected.
 - (2) with high voltage cables only.
 - (3) without high voltage cables connected.

5.1. Analysis

(1) and (2) have to look almost the same (symmetry and amplitude).

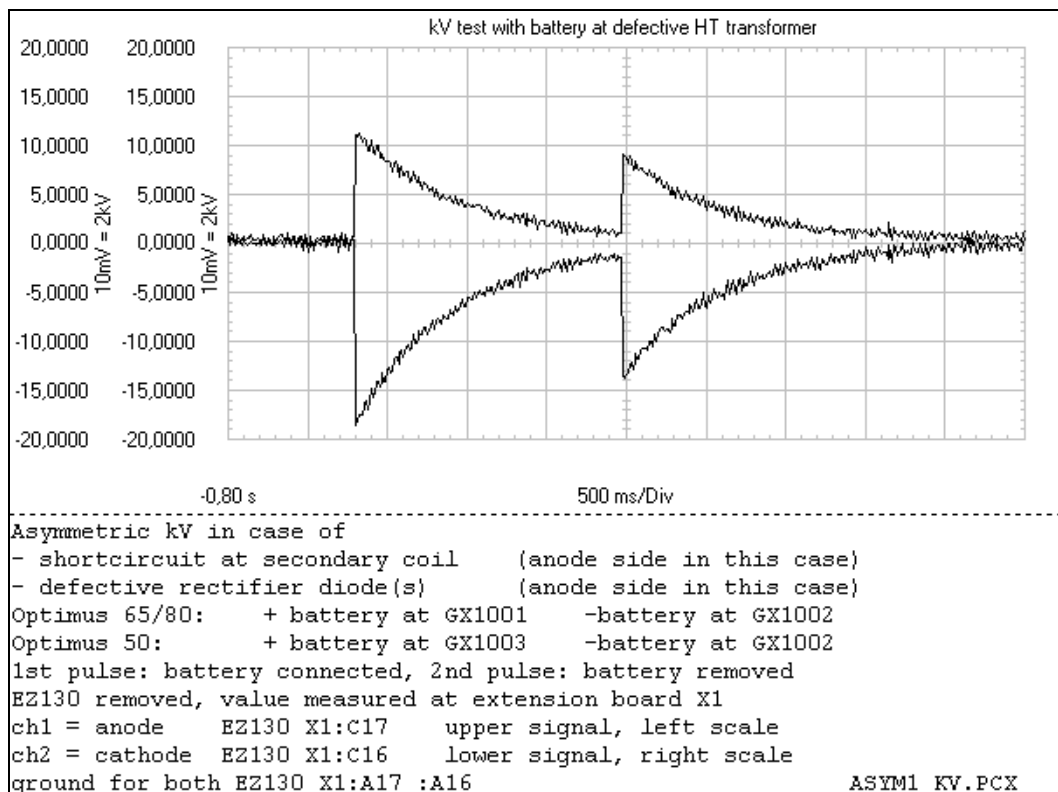
If (1) has a lower amplitude or a different kV behavior compared to (2) and (3) the tube might be defective.

(3) should have a steeper (faster) discharging ramp as the capacitance of the HV cable is missing (tank only 3nF, 20m cable typically 1.5nF) assuming amplitude and symmetry are the same.

If (2) and (3) look different (amplitude and symmetry) and if (3) is symmetric the HV cable(s) might be defective.

If (3) shows an asymmetric amplitude the HV tank must be replaced.

- Check against the following chart:



6. Visual check of the X-ray tube

- If possible remove the collimator and the X-ray tube window assembly.
is there any visible damage?
A cracked tube or the loss of its vacuum could be a reason to destroy the converter.
- Record the conditions in the appendix.

7. Interim results

At this point

- generator parts and units
- tube(s)
- HV cables

have been checked.

Something might have been exchanged or all tests came to an OK-result.

- Remove the extender PCB and reinsert kV-control EZ130.

**WARNING!**
All followings checks must be made with mains power.
Check that the converter mains lines still have no connection to
mains at ENK1 :1 :3 :5

- Switch ON all generator breakers and the mains supply.

8. Tube check with Rotor Control part 1

In case the tube was rotating during tripping of mains breakers the CPU remembers that the brake process has not been carried out (high speed rotor control only).
About 40 seconds after switch-ON the tube brakes.

NOTE!

If the anode disk is not rotating before switch-ON it sounds like an acceleration process.

- Switch ON the generator and perform an audible check at the tube housing during the generator start-up (for further explanations see chapter 10.)

As the mains lines are not connected to the converters, error messages 02HI and 02HJ come up (converter DC is 0V, therefore out of range).

9. kV-driver test

- Perform the kV-driver test according to chapter 5.3 of the Converter R/F manual attached.

If the kV-driver test is successful prepare the generator for a next test:

**WARNING!**

Switch the generator OFF.

Cut the generator completely from mains.

- Lead the primary power cable(s) of QC13:1 (front and rear) through the current transformer(s) at each converter and reestablish the connection to the capacitor.

Optimus 65/80 with 2 converters:

Both current transformers must be inserted the same way.

(Polarity, secondary transformer pins are marked with 1 and 2).

- Reestablish primary cable(s) at QC3:1 too.
- Reestablish all connections (mains cables of converter(s) at ENK1 :1 :3 :5.

10. Tube check with Rotor Control part 2

- Switch ON the generator.
The system and the generator should be in ready condition.

Check of the tube vacuum:

- Push and hold PREP.
- Switch OFF the generator.
The anode is in free run now.
- Listen at the tube housing:
 - If the anode speed is down within 2 ... 3 minutes the tube is defective (no vacuum) and must be replaced.
 - If a decrease of anode speed is not audible within several minutes the vacuum is still OK.
- Switch the generator back ON.
 - A generator with high-speed rotor control brakes the tube automatically (chapter 8).
 - At generators with low -speed rotor control wait for ready condition, push PREP once and let go of the PREP switch to brake the tube.

11. Tube and high-voltage cable test with high voltage

Even if

- the battery test to check a short at the high voltage cables (chapter 5),
- the visual tube check (chapter 6) and
- the audible tube check (chapters 8 + 10)

did not lead to defective parts at first sight, these might be discovered once high voltage is up again.

Therefore the following test procedure was created to switch exposures just for 1ms before any part of the generator might be overloaded from a defective tube or HV cable.

- Switch the generator OFF.
- Establish the **test cable with diode** at the backpanel service measuring points:
EZX74 (CTRL_X_C/ = cathode of diode) > open plug
and
EZX77 (X_ACT_S/ = anode of diode) > green plug cover
- Establish **just one side** first (with the 4mm plug) of the **test cable with resistor** at the mAs short-circuit plug (either side, short-circuit plug remains in) of the measuring circuit EG100 (if access is not possible loosen screening cap of primary lines.)
- Establish oscilloscope connections:
channel 1 = anode EZ130 X4 AV_AN 20kV = 1V 0.5V/div
channel 2 = cathode (also positive) EZ130 X5 AV_CA 20kV = 1V 0.5V/div
ground = EZ130 X6/X32 GNDA
trigger = signal CTRL_X_C/ at EZX74 **must** be used , negative slope, trigger level 2.5V
(if a third probe is not available use one channel for triggering with CTRL_X_C/ and check anode and cathode side individually)
time base = 200µs/div, trigger delay -1div

Explanation:

With these hardware modifications and exposure settings the exposure time is only 1ms.

The additional resistor simulates an emission current of 500mA which lets the mAs counter of mA-control terminate the exposure at 1ms (= 0.5mAs).

Under normal conditions the mAs counter is triggered by the signal X_ACT_S/. As this might be missing due to a problem in the system the additional diode drives, the kV start command CTRL_X_C/ also at X_ACT_S/ to trigger the mAs counter and ensures the short exposure. The oscilloscope must be triggered with CTRL_X_C/ for the same reason to get a display.

- Switch ON the generator.
- Set one RGDV for the following procedure or create a new RGDV just for the test (ignore other settings in Data Set A):

Enable handswitch at generator desk:	Yes
Syncmaster present (e.g. grid contact):	No
Exposure switch type:	Double Step
Mounted radiographical controller:	none
Release circuit adaptation unit:	none
Mounted tomo extension:	none

- Start with **40kV, 50mA, 10ms** (= 0.5mAs). If the tube is not adapted set **40kV 0.5mAs**.
- Establish the **second side** of the **test cable with resistor** at backpanel plug EZX18 (Optimus 50)
or
EZX19 (OM 65/80) (backpanel layout page Z2-5.2).
If EZX19 is used take 1WA X42 or 2WA X42 or 1WB X42 (see layout Z2-15.1).

NOTE!

If the test cable with resistor is connected, mA-control EZ119 might display a FATAL error condition (LED on) after a certain time. Then remove the plug and warmstart the generator.

Do not put the plug back in before the generator is in ready condition. Then continue.

- Switch one exposure.
- Compare the measured result with the four possible cases of the table.

Case 1:

Both, anode and cathode side, have the same kV rising slope and value up to the point when the exposure terminates (which is almost the set kV).

If so, increase kV value in 10kV steps up to the programmed max kV tube limit or the max. value which is used for application and check results with the table cases 1, 2 and 3 accordingly (settings 50mA + 10ms or 0.5mAs for a non-adapted tube **must remain!**).

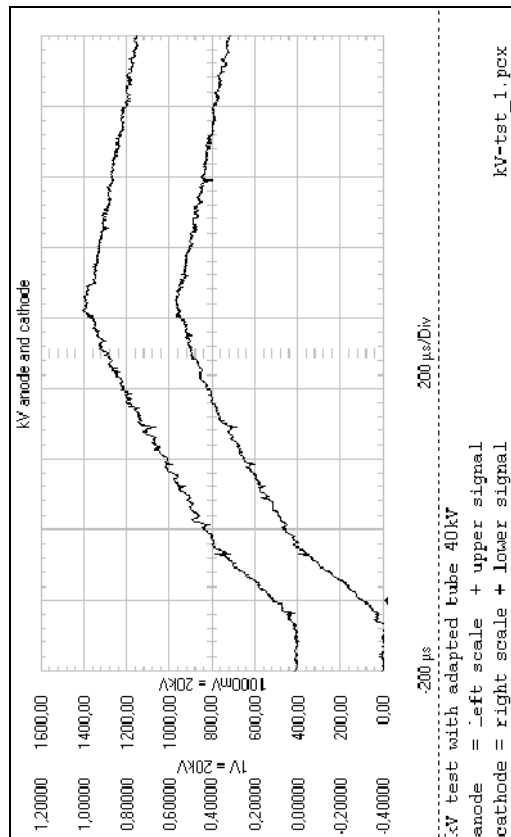
If the result is not case 1 carry out case dependent **actions** given in the table below and switch a second exposure.

CAUTION!

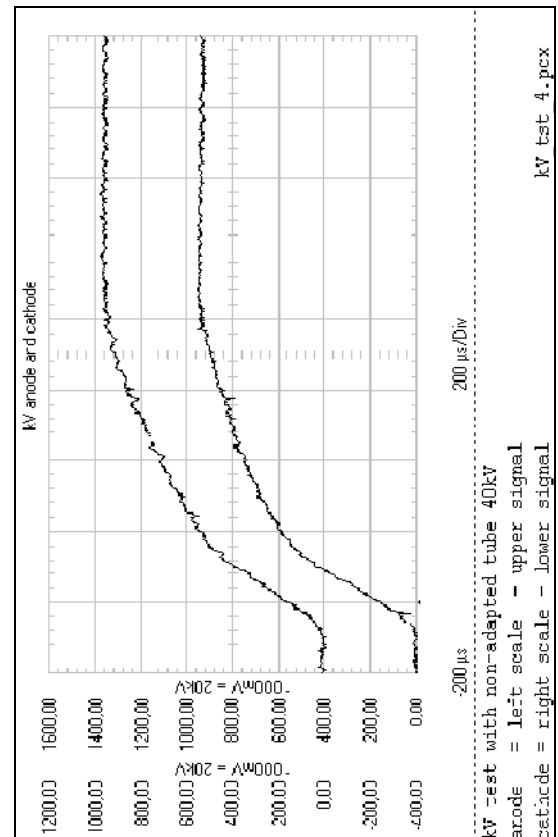
Case 4 must not be carried out with a value higher than 40kV.

exposures to be switched with 50mA 10ms or 0.5mAs		measuring results		<u>actions</u> + ► analysis	
		anode EZ130 X4	cathode EZ130 X5	HV cable	tube
case 1	one exposure	50% of set kV	50% of set kV	► OK	► OK
				<i>increase kV by 10kV</i>	
case 2	1 st exposure	$0 \neq \text{anode kV} < \text{cathode kV} \neq 0$ or $0 \neq \text{anode kV} > \text{cathode kV} \neq 0$		<u>interchange anode and cathode HV cables (at both sides, tube and transformer)</u> no change of measured levels: ► tube defective measured levels change: ► HV cable(s) defective	
	2 nd exposure				
case 3	1 st exposure	set kV or 0kV	0kV or set kV	<u>interchange anode and cathode HV cables (at both sides, tube and transformer)</u> ► HV cable at the 0kV side defective	
	2 nd exposure	0kV or set kV	set kV or 0kV		
case 4	1 st exp. 40kV	0kV	0kV	<u>remove anode HV cable from tube and HV transformer side</u> ► tube defective	
	2 nd exp. 40kV	40kV or 20kV	0kV or 20kV		

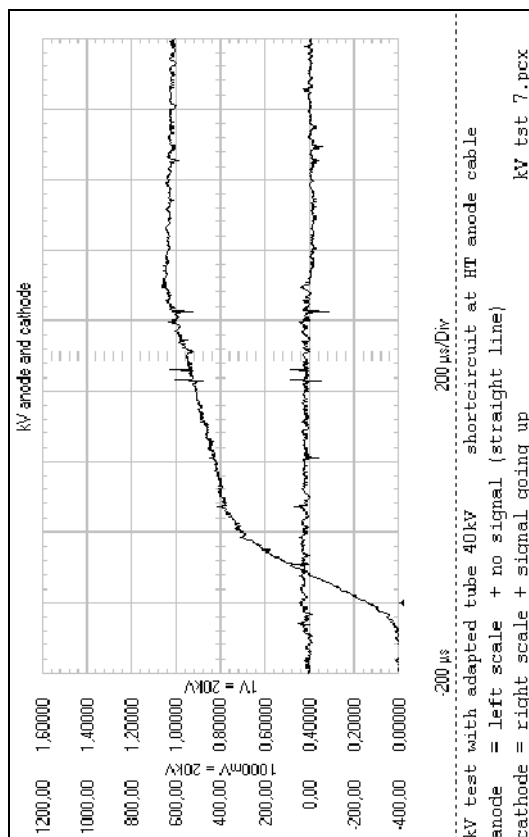
- Compare measuring results with examples of oscilloscope charts on next page.
- **Remove test cables with resistor and diode!**



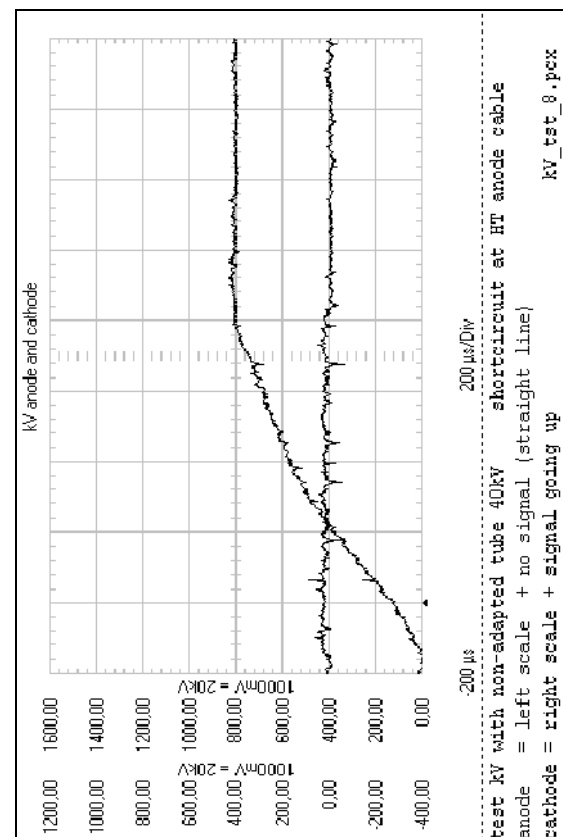
▲ adapted tube, tube and cable OK ▲



▲ non-adapted tube, tube and cable OK ▲



▲ adapted tube, anode cable short-circuit ▲



▲ non-adapted tube, anode cable short-circuit ▲

12. Measuring of primary currents

- Switch OFF the generator and wait 1 minute for the converter DC to be discharged.
- Measure with the oscilloscope:

Signals:

Optimus 50:

Establish one oscilloscope probe (signal and screen) at the current transformer secondary side.
Establish the second probe at EZ130 X3 AV_HT (actual value high voltage) and ground EZ130 X6.

Optimus 65/80:

Establish both oscilloscope probes at the current transformers secondary side.
Check that signal and ground are at the same 1 + 2 transformer connections (polarity).

Trigger:

Use external trigger negative slope with low active CTRL_X_C/ signal at EX74 (backpanel).
If a third probe for an external trigger is not available:

Optimus 50:

Use channel 2 (kV actual value AV_HT = 20kV/Volt) positive slope, trigger value according to probe divider.

Optimus 65/80:

Set the trigger point level at channel 1 or 2 according to the expected amplitudes (see charts).

Time base:

According to charts. A trigger delay time (settings see charts) can be useful to see the start of the signals.

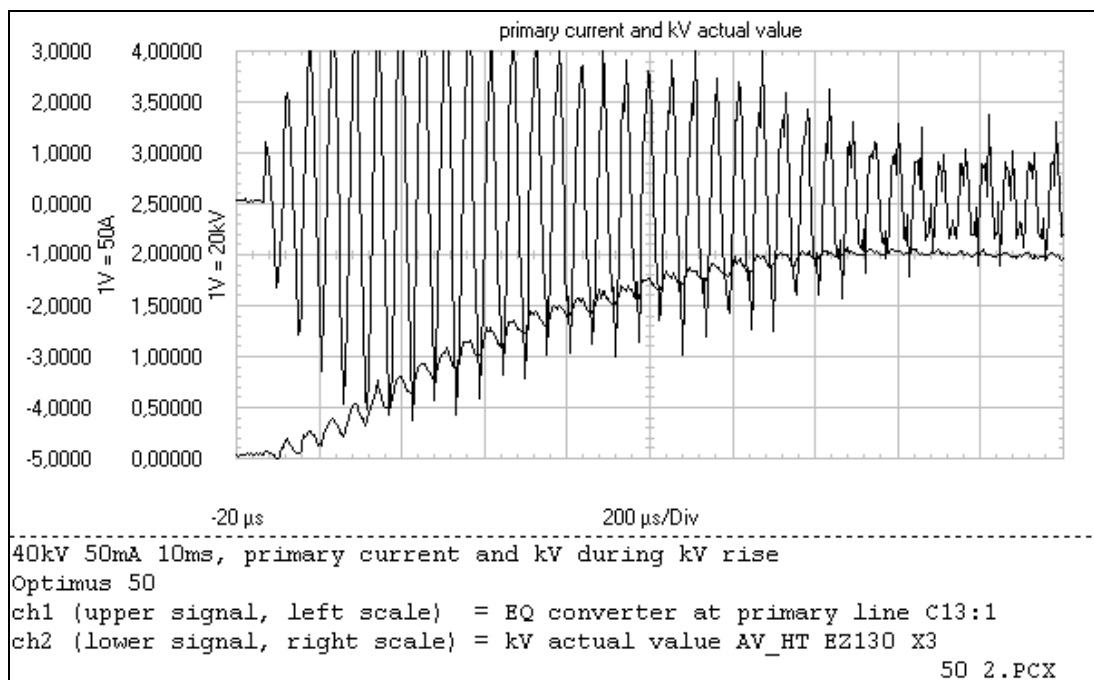
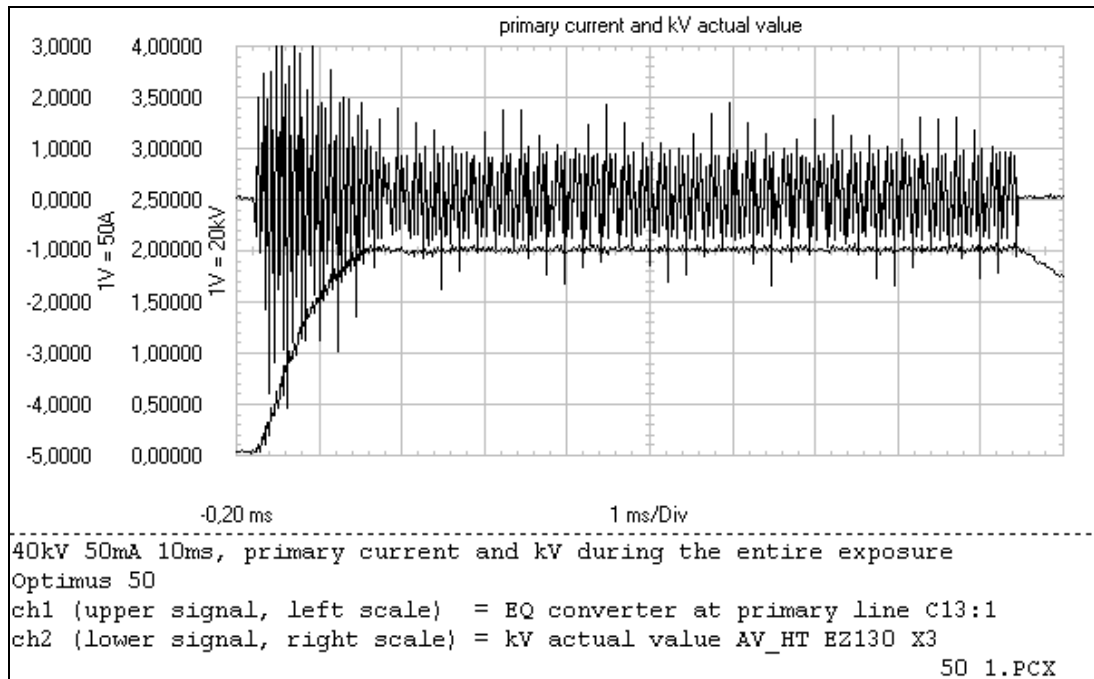
NOTE!

Digital oscilloscopes sometimes display waveforms and spikes which do not exist or only parts of the signal are displayed.

The following charts were made with a 100MHz oscilloscope with different magnification factors (= time base).

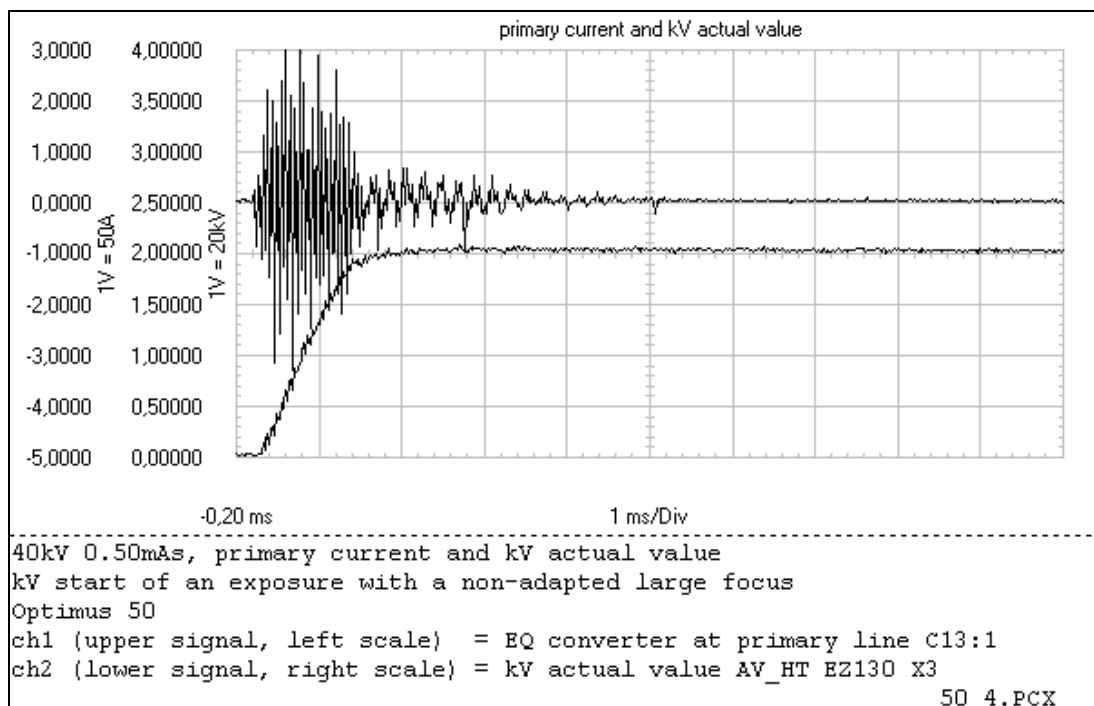
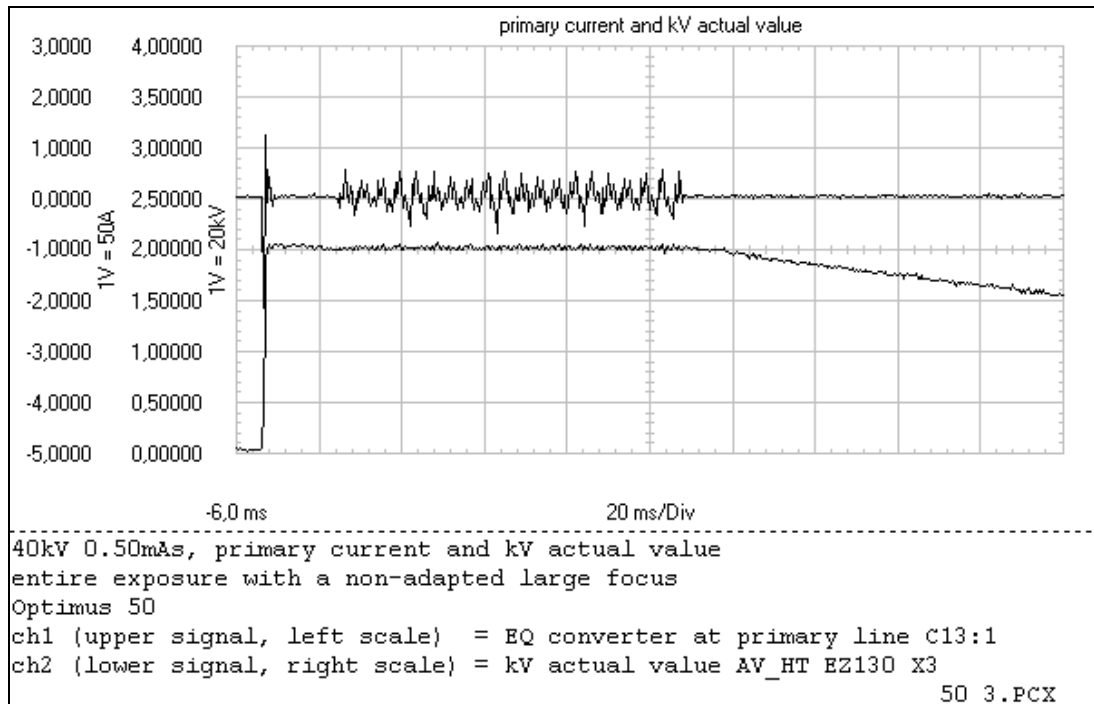
- Switch the generator back ON.
- Set **40kV, 50mA, 10ms** (any focus). In case the tube is not adapted set **40kV, 0.5mAs**.
- Compare waveforms with the charts on the following 4 pages.

Optimus 50 tube adapted:



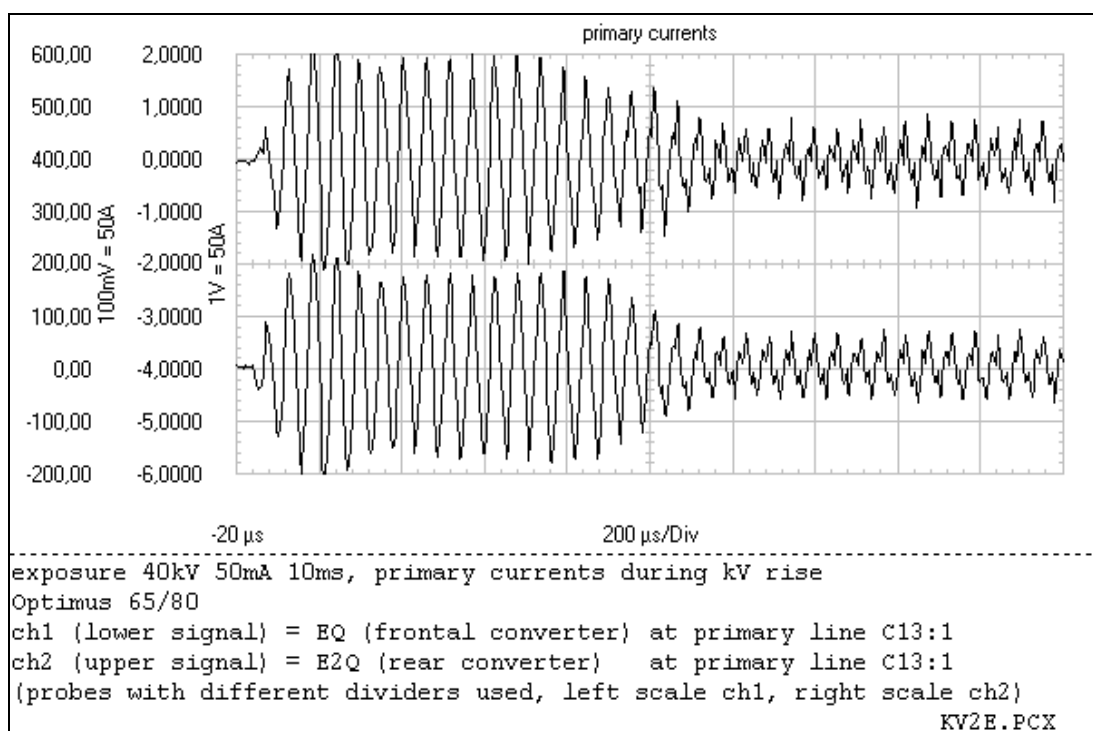
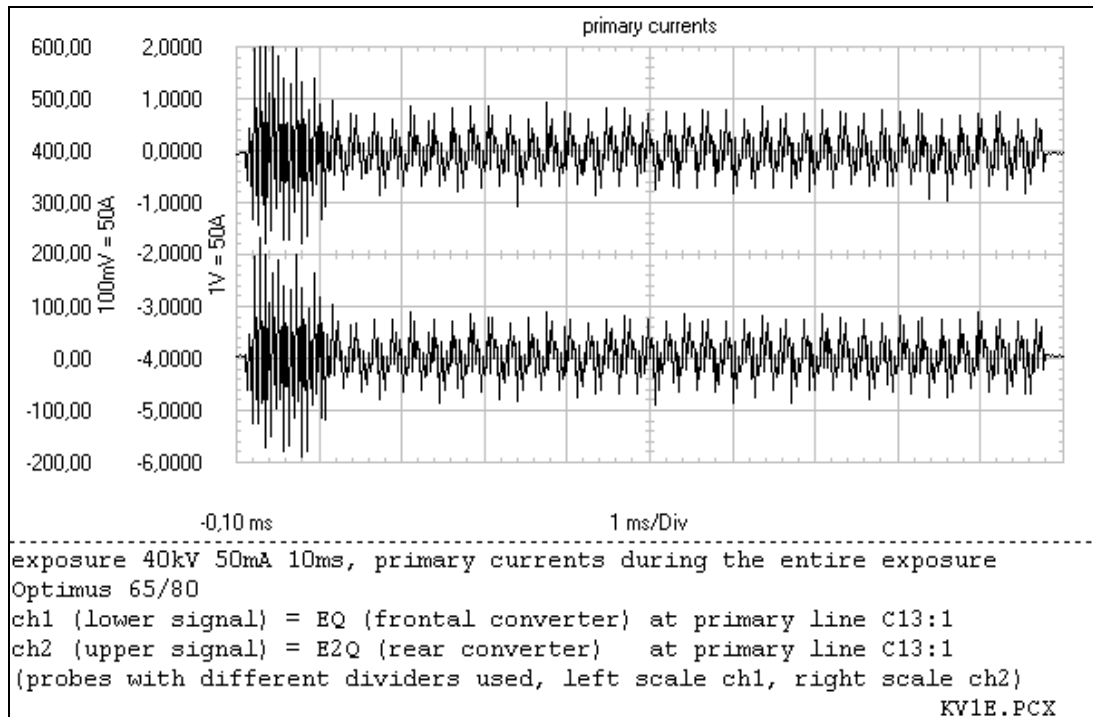
The primary current values must be within the range of the lower chart $\pm 10\%$.

Optimus 50 tube not adapted:



The primary current values must be within the range of the lower chart of page 26 $\pm 10\%$.

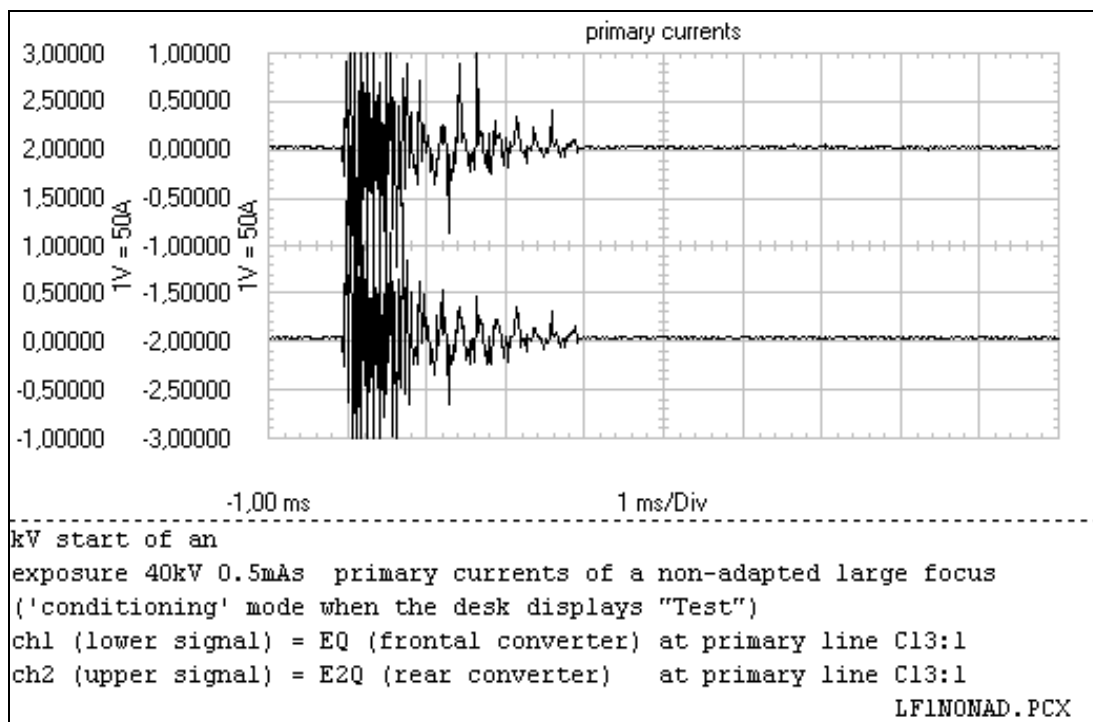
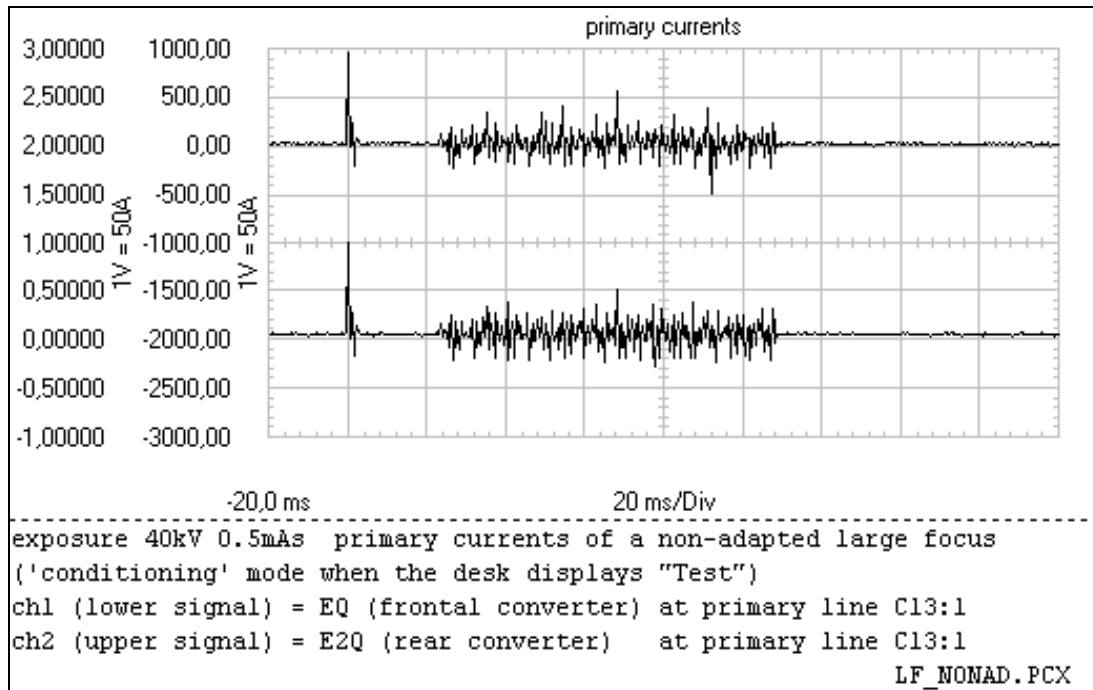
Optimus 65/80 tube adapted:



If waveforms are not symmetrical replace HV transformer.

The primary current values must be within the range of the lower chart $\pm 10\%$.

Optimus 65/80 tube not adapted:



If waveforms are not symmetrical replace HV transformer.

The primary current values must be within the range of the lower chart of page 28 $\pm 10\%$.

12.1. Measuring of the resonance frequency

The resonance frequency of

- the parallel primary coils (anode and cathode) at a 50kW generator driven by 1 converter only
- or
- the individual primary coils (anode or cathode) at a 65/80kW driven by 1 converter each

must always be the same.

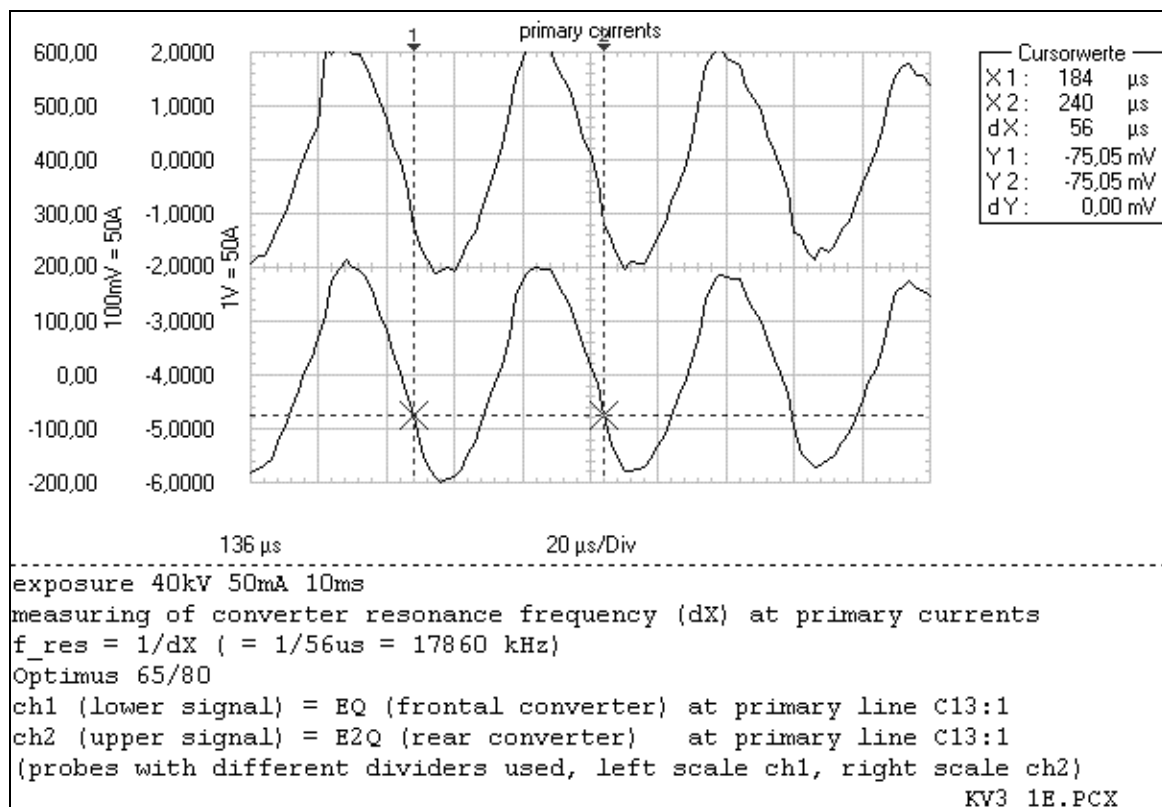
With a tolerance of 5% for the primary coil inductance and for the resonance capacitors in the converters the resonance frequency must be within a range of 17.160kHz ($1/f = 58.3\mu s$) and 18.970kHz ($1/f = 52.7\mu s$).

Optimus **65/80** with **2** converters:

Both currents must be in phase (if not check probes at current transformer pins 1 + 2).

- Compare with chart.

It does not matter if the tube is adapted or not.



Optimus **50**:

If the resonance frequency is not within the specified range the suspected part might be

- the HV transformer
- the resonance capacitor(s) of the converter.

Optimus **65/80**:

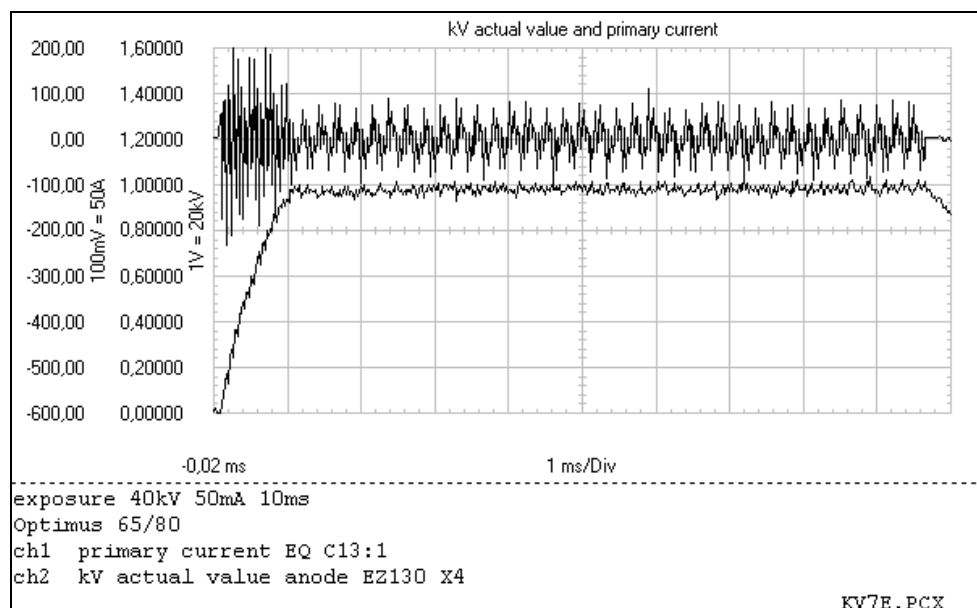
Both resonance frequencies must be within the specified range. If not the suspected part might be

- the HV transformer
- the resonance capacitor(s) of the individual converter.

12.2. Measurement of kV behavior with an adapted tube

- Switch OFF the generator and wait until the converter DC is discharged.
- Establish one oscilloscope probe at EZ130 X4 AV_AN actual value high voltage **anode** and ground EZ130 X6.
Settings see chart.
The second probe remains at the primary current anode side (frontal converter 65/80kW or the frontal converter of Optimus 50).
- Switch an exposure and compare with chart.
- Establish one oscilloscope probe at EZ130 X5 AV_CA actual value high voltage **cathode** (also positive) and ground EZ130 X6.
- Establish the second probe at the primary current cathode side (rear converter 65/80kW).
- Switch an exposure **40kV, 50mA, 10ms** and compare with chart.

Tube adapted:



If kV values are not symmetrical replace HV transformer. Asymmetry error messages like 02HW (warning in the background) or 02HX (error) might also come up (measured values see detail screens error log).

Tube arcing messages like 02WG (warning in the background) or 02WH (error) might appear. These should be visible at the oscilloscope trace as break-in of kV within a time of $< 10\mu\text{s}$.

It might be a problem of the tube, either because of its age or because it has not properly been conditioned.

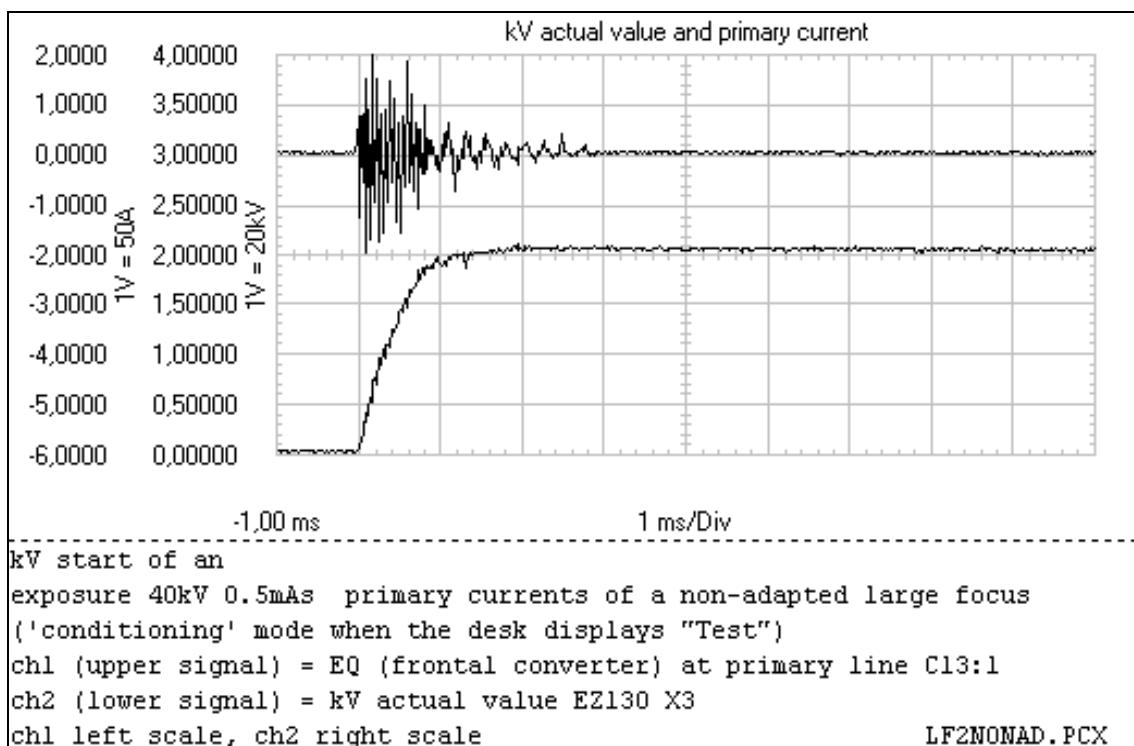
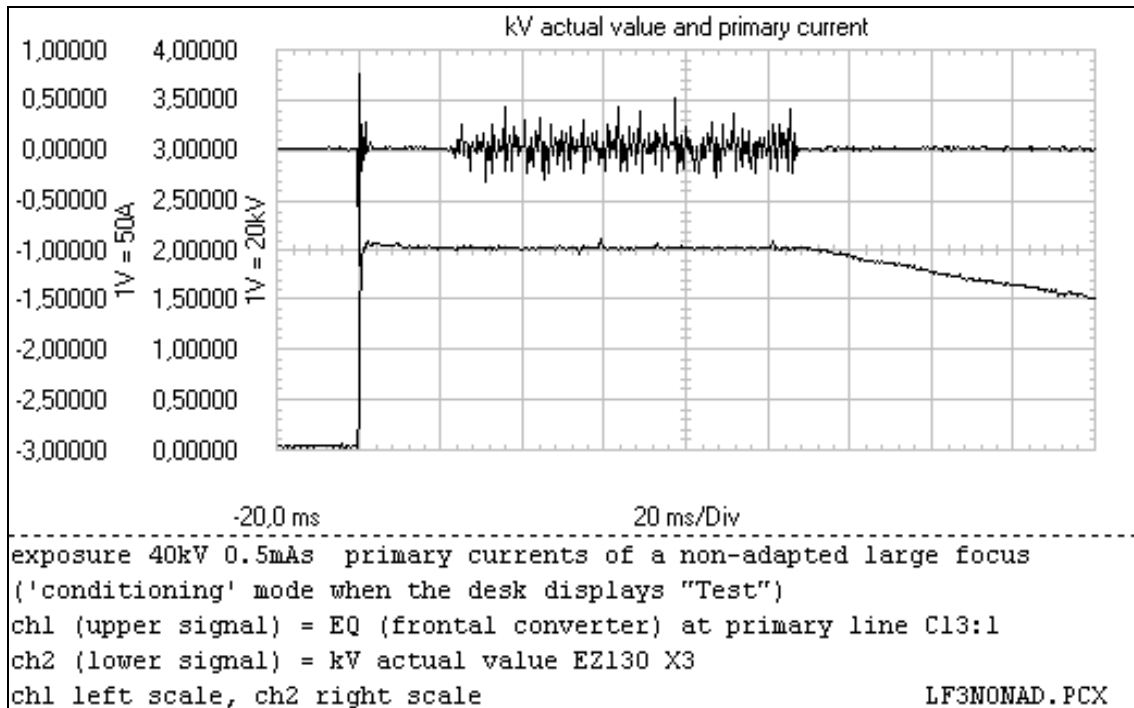
In case of errors 02HG (warning in the background) and 02HH (error) realign the duty cycle factor according to ADJUSTMENTS chapter 2 revision provided with the kit.

File the document in the SUBSYSTEM manual OPTIMUS.

If a filament is not adapted adapt it before realigning the duty cycle; otherwise the adjustment is not possible.

12.3. Measuring of kV behavior with a non-adapted tube (Optimus 65/80)

The primary current behavior is different to an adapted condition as the exposure starts with 2A filament current which is brought up to filament current limit of the selected focus once high voltage is at its nominal value. Measurements have been made at kV actual value AV_HT EZ130 X3. To check the kV symmetry use the settings of chapter 12.2.



13. Reconditioning of the tube(s)

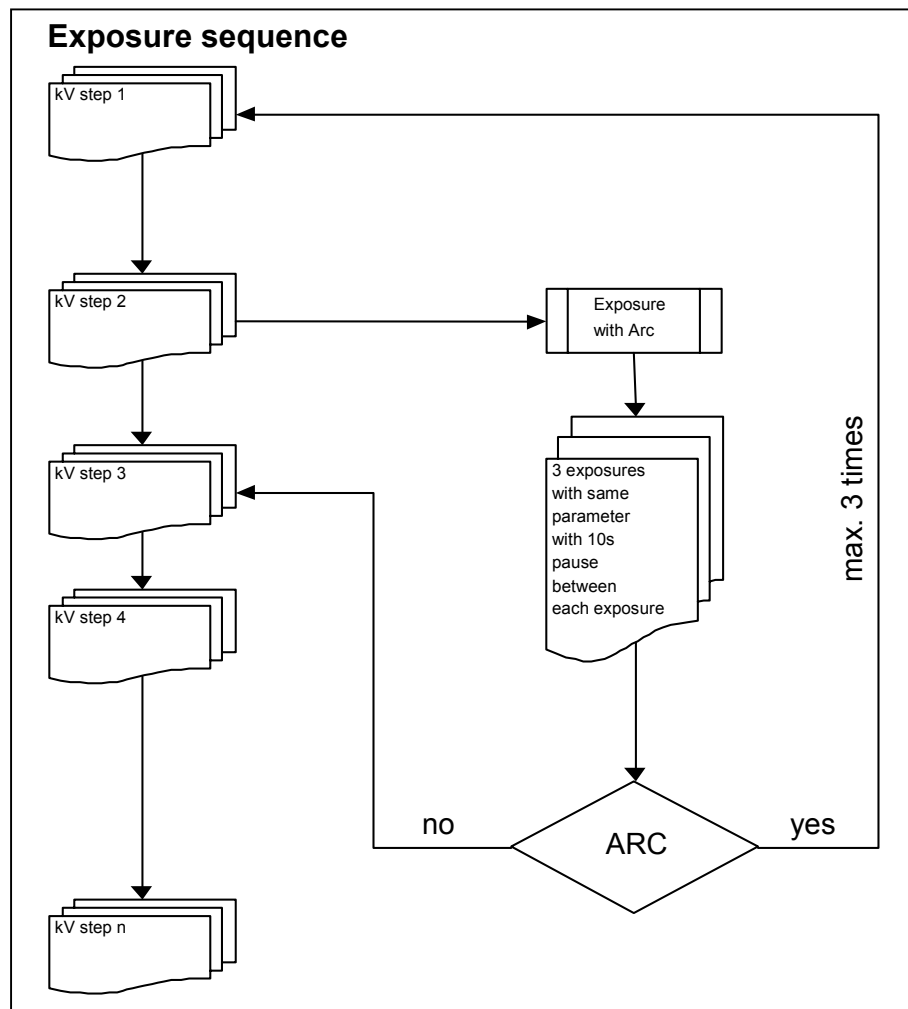
- Establish one oscilloscope probe at EZ130 X3 AV_HT actual value high voltage (total kV, 20kV/V) and ground EZ130 X6.

Use large focus only!

- Run reconditioning procedure (see next page) for the applicable kV range only.
If, for instance, 125kV is the max. kV value during normal application, perform reconditioning just up to the next kV step = 130kV.

If the tube arcs at a certain kV value proceed as follows:

- Switch another 3 exposures with same parameters and 10s pause between subsequent exposures.
- If the last exposure of a sequence does not arc proceed with next kV step.
- If the last exposure still arcs go one kV step back and start again with the normal procedure.
If this routine has been performed three times without improvement: **==> replace the tube!**



NOTE!

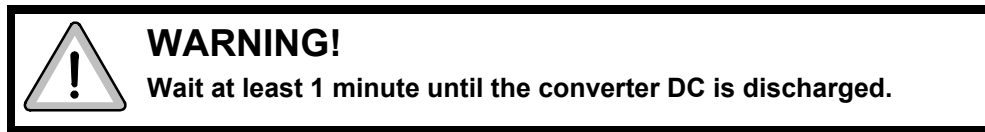
If a tube arcs at a kV value which is not required for application the max kV (e.g. 125kV) value can be reduced with

XRGSCOPE >> PROGRAM >> TUBES >> TUBE LIMITS >> MAX. TUBE VOLTAGE LIMIT [KV]: [125]

Tube adapted				Tube not adapted	
Switch the number of exposures given for every data set of the table.					
kV	mA	ms	exposures	kV	mAs
80	10	50	< 1 >	80	0.5
80	10	500	< 1 >	80	5
80	200	250	< 1 >	80	50
10 seconds pause				10 seconds pause	
80	max mA	100	< 1 >	80	100
1 minute pause				1 minute pause	
90	10	50	< 1 >	90	0.5
90	10	500	< 1 >	90	5
90	200	250	< 1 >	90	50
10 seconds pause				10 seconds pause	
90	max mA	100	< 1 >	90	100
1 minute pause				1 minute pause	
100	10	50	< 1 >	100	0.5
100	10	500	< 1 >	100	5
100	200	250	< 1 >	100	50
10 seconds pause				10 seconds pause	
100	max mA	100	< 1 >	100	100
1 minute pause				1 minute pause	
110	10	50	< 1 >	110	0.5
110	10	500	< 1 >	110	5
110	200	250	< 1 >	110	50
10 seconds pause				10 seconds pause	
110	max mA	100	< 1 >	110	100
1 minute pause				1 minute pause	
120	10	50	< 1 >	120	0.5
120	10	500	< 1 >	120	5
120	200	250	< 1 >	120	50
10 seconds pause				10 seconds pause	
120	max mA	100	< 1 >	120	100
1 minute pause				1 minute pause	
130	10	50	< 1 >	130	0.5
130	10	500	< 1 >	130	5
130	200	250	< 1 >	130	50
10 seconds pause				10 seconds pause	
130	max mA	100	< 1 >	130	100
1 minute pause				1 minute pause	
140	10	50	< 1 >	140	0.5
140	10	500	< 1 >	140	5
140	200	250	< 1 >	140	50
10 seconds pause				10 seconds pause	
140	max mA	100	< 1 >	140	100
1 minute pause				1 minute pause	
145	10	50	< 1 >	145	0.5
145	10	500	< 1 >	145	5
145	200	250	< 1 >	145	50
10 seconds pause				10 seconds pause	
145	max mA	100	< 1 >	145	100
1 minute pause				1 minute pause	
148	10	50	< 1 >	148	0.5
148	10	500	< 1 >	148	5
148	200	250	< 1 >	148	50
10 seconds pause				10 seconds pause	
148	max mA	100	< 1 >	148	100
1 minute pause				1 minute pause	
150	10	50	< 1 >	150	0.5
150	10	500	< 1 >	150	5
150	200	250	< 1 >	150	50
10 seconds pause				10 seconds pause	
150	max mA	100	< 1 >	150	100

14. Final system test

- If the generator works error-free at this stage switch it OFF and cut it from mains.



- Remove current transformer(s) from the primary lines and reestablish the primary lines at the resonance capacitors.
- Close the converter covers.
- Put mains and the generator back ON.
- Run a final system test with exposures and fluoroscopy where present.

List of checked parts of generator S/N: _____

Please add this list to returned parts.

ENK2	phase 1	1 - 2	☐ open	☐ welded
	phase 2	3 - 4	☐ open	☐ welded
	phase 3	5 - 6	☐ open	☐ welded

EN	: R1	☐ open
	: R2	☐ open
	: R3	☐ open

ENF1	L1 – T1	☐ open	☐ welded
	L2 – T2	☐ open	☐ welded
	L3 – T3	☐ open	☐ welded

ENF2	L1 – T1	☐ open	☐ welded
	L2 – T2	☐ open	☐ welded
	L3 – T3	☐ open	☐ welded

ENK1	phase 1	2 – 1	☐ open	☐ welded
	phase 2	4 – 3	☐ open	☐ welded
	phase 3	6 – 5	☐ open	☐ welded

Rectifier EQV5	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
-----------------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

IGBT 1	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
---------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

IGBT 2	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
---------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

IGBT 3	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
---------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

IGBT 4	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
---------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

Diode V501	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
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Diode V502	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
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Diode V503	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
-------------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

Diode V504	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
-------------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

Resistors R506/507/508	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
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Resistors R509/510/511	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
-------------------------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

Cable harness	EQ	☐ 2 = OK	☐ 1 = defective	E2Q	☐ 2 = OK	☐ 1 = defective
----------------------	----	---------------------------------	--	-----	---------------------------------	--

>> Converter	EQ	☐ OK	☐ defective	unit barcode# frontal: _____
	E2Q	☐ OK	☐ defective	unit barcode# rear (65/80kW only): _____

Res. capacitor C3	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
--------------------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

Res. capacitor C13	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
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H.V. cable	☐ OK	☐ defective
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X-Ray tube 1	☐ OK	☐ defective	tube type: _____	tube S/N: _____
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X-Ray tube 2	☐ OK	☐ defective	tube type: _____	tube S/N: _____
---------------------	-----------------------------	------------------------------------	------------------	-----------------

H.V. transformer	☐ OK	☐ defective	tank S/N: _____
-------------------------	-----------------------------	------------------------------------	-----------------

List of checked parts of generator S/N:

Please add this list to returned parts.

ENK2	phase 1	1 - 2	☐ open	☐ welded
	phase 2	3 - 4	☐ open	☐ welded
	phase 3	5 - 6	☐ open	☐ welded

EN	: R1	☐ open
	: R2	☐ open
	: R3	☐ open

ENF1	L1 – T1	☐ open	☐ welded
	L2 – T2	☐ open	☐ welded
	L3 – T3	☐ open	☐ welded

ENF2	L1 – T1	☐ open	☐ welded
	L2 – T2	☐ open	☐ welded
	L3 – T3	☐ open	☐ welded

ENK1	phase 1	2 – 1	☐ open	☐ welded
	phase 2	4 – 3	☐ open	☐ welded
	phase 3	6 – 5	☐ open	☐ welded

Rectifier	EQV5	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
------------------	-------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

IGBT 1	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
---------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

IGBT 2	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
---------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

IGBT 3	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
---------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

IGBT 4	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
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Diode V501	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
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Diode V502	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
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Diode V503	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
-------------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

Diode V504	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
-------------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

Resistors R506/507/508	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
-------------------------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

Resistors R509/510/511	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
-------------------------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

Cable harness	EQ	☐ 2 = OK	☐ 1 = defective	E2Q	☐ 2 = OK	☐ 1 = defective
----------------------	----	---------------------------------	--	-----	---------------------------------	--

>> Converter	EQ	☐ OK	☐ defective	unit barcode# frontal: _____
	E2Q	☐ OK	☐ defective	unit barcode# rear (65/80kW only): _____

Res. capacitor C3	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
--------------------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

Res. capacitor C13	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
---------------------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

H.V. cable	☐ OK	☐ defective
-------------------	-----------------------------	------------------------------------

X-Ray tube 1	☐ OK	☐ defective	tube type: _____	tube S/N: _____
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X-Ray tube 2	☐ OK	☐ defective	tube type: _____	tube S/N: _____
---------------------	-----------------------------	------------------------------------	------------------	-----------------

H.V. transformer	☐ OK	☐ defective	tank S/N: _____
-------------------------	-----------------------------	------------------------------------	-----------------

List of checked parts of generator S/N:

Please add this list to returned parts.

ENK2	phase 1	1 - 2	☐ open	☐ welded
	phase 2	3 - 4	☐ open	☐ welded
	phase 3	5 - 6	☐ open	☐ welded

EN	: R1	☐ open
	: R2	☐ open
	: R3	☐ open

ENF1	L1 – T1	☐ open	☐ welded
	L2 – T2	☐ open	☐ welded
	L3 – T3	☐ open	☐ welded

ENF2	L1 – T1	☐ open	☐ welded
	L2 – T2	☐ open	☐ welded
	L3 – T3	☐ open	☐ welded

ENK1	phase 1	2 – 1	☐ open	☐ welded
	phase 2	4 – 3	☐ open	☐ welded
	phase 3	6 – 5	☐ open	☐ welded

Rectifier	EQV5	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
------------------	-------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

IGBT 1	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
---------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

IGBT 2	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
---------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

IGBT 3	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
---------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

IGBT 4	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
---------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

Diode V501	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
-------------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

Diode V502	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
-------------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

Diode V503	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
-------------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

Diode V504	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
-------------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

Resistors R506/507/508	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
-------------------------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

Resistors R509/510/511	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
-------------------------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

Cable harness	EQ	☐ 2 = OK	☐ 1 = defective	E2Q	☐ 2 = OK	☐ 1 = defective
----------------------	----	---------------------------------	--	-----	---------------------------------	--

>> Converter	EQ	☐ OK	☐ defective	unit barcode# frontal: _____
	E2Q	☐ OK	☐ defective	unit barcode# rear (65/80kW only): _____

Res. capacitor C3	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
--------------------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

Res. capacitor C13	EQ	☐ OK	☐ defective	E2Q	☐ OK	☐ defective
---------------------------	----	-----------------------------	------------------------------------	-----	-----------------------------	------------------------------------

H.V. cable	☐ OK	☐ defective
-------------------	-----------------------------	------------------------------------

X-Ray tube 1	☐ OK	☐ defective	tube type: _____	tube S/N: _____
---------------------	-----------------------------	------------------------------------	------------------	-----------------

X-Ray tube 2	☐ OK	☐ defective	tube type: _____	tube S/N: _____
---------------------	-----------------------------	------------------------------------	------------------	-----------------

H.V. transformer	☐ OK	☐ defective	tank S/N: _____
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ADJUSTMENTS

TEXT

Contents	6-0.1
1. Area Dose Calculator (option)	6-1
1.1. Checking the default adjustment	6-2
1.2. Correction of the specific yield	6-3
1.3. Correction of the filter values	6-5
2. Alignment of "Function Unit kV"	6-8
2.1. General information	6-8
2.2. Connecting and setting the scope	6-10
2.3. Deactivating the kV controller	6-11
2.4. Setting of exposure data	6-11
2.5. Adjustment of the "factor for duty cycle"	6-12
3. Dose rate alignment for continuous fluoroscopy when using the dose-rate signal DR TV (formerly ADC) // dose-rate control via TV-chain	6-15
3.1. Aim	6-15
3.2. Principle	6-16
3.3. Alignment of DR TV with the oscilloscope	6-18
4. Maximum patient entrance dose rate: Entrance Dose rate Limiter (EDL)	6-23
4.1. Aim	6-23
4.2. Principle	6-23
4.3. Alignment	6-23

1. Area Dose Calculator (option)

Special tools:

- calibrated dosimeter, e.g. DALI with measuring cell 77334 or PMX3
- 1mm lead plate

The following parameters are relevant for calculation:

- SID (**S**ource **I**mage **D**istance)
- diaphragm aperture
- added filters
- specific yield of tube
- mAs product
- number of exposures

SID, diaphragm aperture and type of filters are supplied by the diagnostic unit, where they are also adjusted.

In the generator default values are given for the specific yield of a tube and filter correction.

These default values can be found as reference files on floppy disk in order to recreate the original settings if need be.

Reference files:

ref_yiel.tdl	specific yield of tube
ref_2al.tdl	filter 2mm Al
ref_01cu.tdl	filter 1mm Al + 0.1mm Cu
ref_02cu.tdl	filter 1mm Al + 0.2mm Cu

The specific yield curve relates to tungsten anodes and 2.5mm primary filters.

Display on the desk is in [cGycm²].

1.1. Checking the default adjustment

- Place the lead plate and the measuring cell of the measuring instrument on the table in the central radiation beam. The purpose of the lead plate is to reduce radiation scatter of the table top. Without the plate the test result would be approximately 10% higher using a table top made, for example, of resin bonded paper.
- Perform the following settings:
 - 1m between the focus and the measuring cell (= SMD **S**ource **M**easuring **D**istance)
 - free cassette technique
 - kV-mAs-s technique
 - 10mAs
 - 0.1s
 - collimation 10 x 10cm at the height of the measuring cell
 - no filter
- Determine area dose at the following kV settings and compare it with the respective value displayed on the desk:

	50kV	80kV (81kV)	120kV (117kV)
displayed product	 cGycm ²	 cGycm ²	 cGycm ²
measured dose	 cGy	 cGy	 cGy
measured area (X x Y)	 cm ²	 cm ²	 cm ²
calculated product	 cGycm ²	 cGycm ²	 cGycm ²
difference	 %	 %	 %

Example:

- displayed area dose product: 8.8cGycm²

- measured dose: 890μGy = 0.089cGy

- calculated area dose product: measured dose × exposed area = 0.089cGy × 100cm² = 8.9cGycm²

- difference in %:
$$= \frac{8.9 - 8.8}{8.9} \times 100 = 1.12\%$$

- If there are any deviations of over 5% it is recommended that the yield curve be corrected in accordance with the procedure described in 1.2.

1.2. Correction of the specific yield

Prerequisite:

- Test setup and settings in accordance with section 1.1.:
 - 1m between the focus and the measuring cell (= SMD)
 - free cassette technique
 - kV-mAs-s technique
 - 10mAs
 - 0.1s
 - collimation 10 x 10cm at the height of the measuring cell
 - no filter

Principle:

- For each kV specified a dose measurement is taken under the same conditions. If the distance between the focus and the measuring cell deviates from 1m, all the dose values must be corrected with the square of distance (unit of measurement is [m]). Dividing the dose values by the mAs product set gives the respective current yield.

Procedure:

- Measure dose at each kV checkpoint and use it to calculate specific yield.

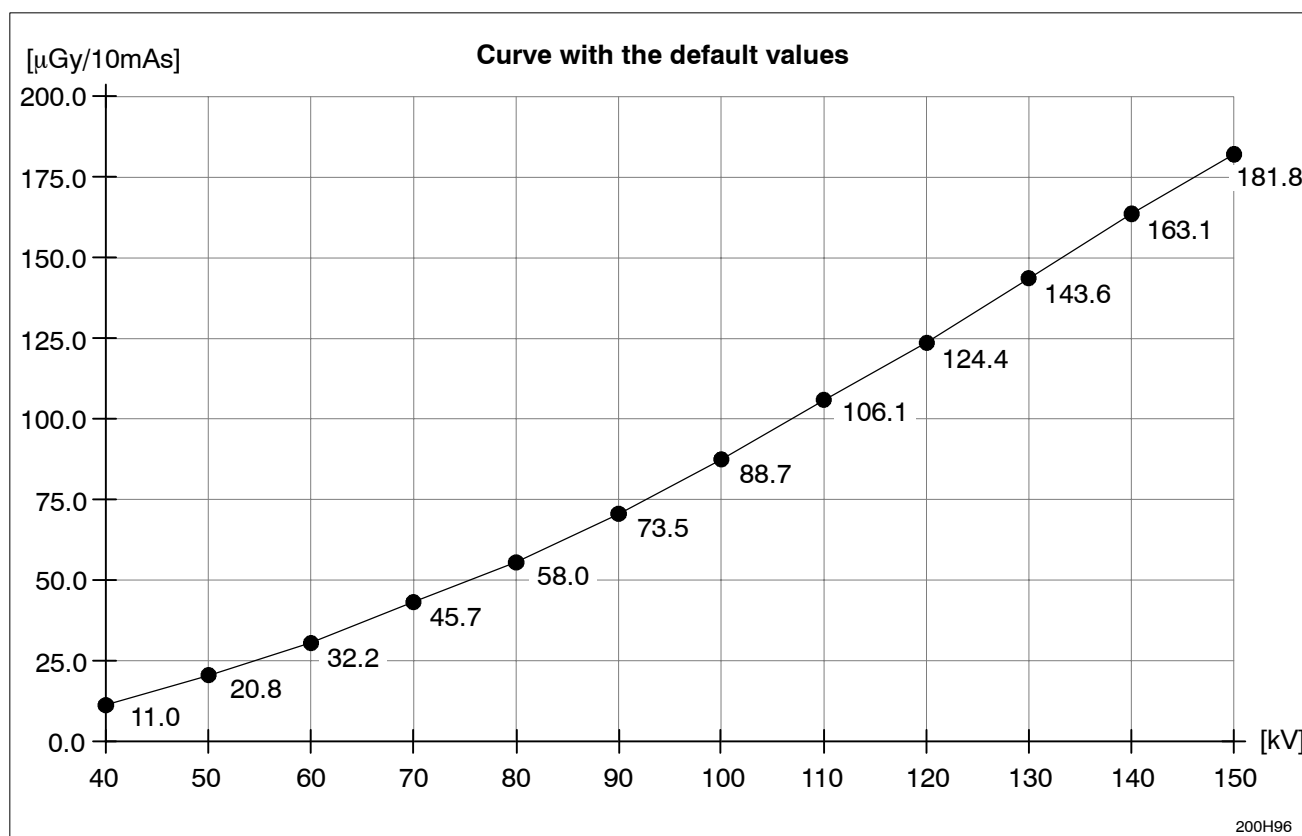
The values determined must be higher at higher kVs settings and produce a characteristic with a slight curve on the graph. If considerable fluctuations are detected, the measurements must be repeated at the points in question.

Range: 0.00 ... 400.00 μ Gy/mAs

The values can only be stored in the generator if they are within the range specified and rise uniformly with kV.

Specific yield

kV checkpoint	40	50	60	70	80	90	100	110	120	130	140	150
default yield [μGy/10mAs]	11.0	20.8	32.2	45.7	58.0	73.5	88.7	106.1	124.4	143.6	163.1	181.8
measured dose [μGy]												
distance ² factor	If the distance focus - measuring cell (= SMD) differs from 1m correct the dose with the factor: distance ² factor = (SMD [m] / 1m) ² = ... (e.g. = 1.44 for a SMD of 1.2m)											
corrected dose [μGy]												
specific yield [μGy/10mAs]	specific yield = corrected dose/10mAs											



- Correct the default values of the specific yield for all the kV checkpoints.
Select menu:
ADJUST/ AREA EXPOSURE PRODUCT/ **SPECIFIC YIELD OF TUBE 1 ... 3**
with the factor determined and save with <TRANSMIT>.
- Save the specific yield curve with the SAVE function of XRGSCOPE <F3> key on the backup disk.
Recommended file name: act_yiel.tdl

1.3. Correction of the filter values

Prerequisite:

- Test setup and settings in accordance with section 1.1.
 - 1m between the focus and the measuring cell (= SMD)
 - free cassette technique
 - kV-mAs-s technique
 - 10mAs
 - 0.1s
 - collimation 10 x 10cm at the height of the measuring cell
 - no filter

Principle:

- At otherwise identical settings the dose is determined for the kV values specified with and without filter. The ratio of dose values with / without filter produces the respective current correction factor.

Procedure:

- Accept measured dose values (not the corrected ones!) for the respective kV checkpoints from yield measurement or measure them again if any changes have been made to the test-setup or settings.
- Move the filter to be checked into the radiation beam.
- Measure dose at each kV checkpoint and enter it in the respective table.

Note

The 40kV range is not used in practice so it does not have to be corrected.

If in the lower kV range the considerably reduced dose can no longer be measured or read perfectly, at that point a higher mAs product must be selected. Then the repeat measurement must be performed without filter.

- Using the ratio between dose with and without filter, determine the respective correction factor.
The values determined must be higher at higher kVs settings and produce a characteristic with a slight curve on the graph. If considerable fluctuations are detected, the measurements must be repeated at the points in question.
Range: 0.000 ... 1.000
The values can only be stored in the generator if they are within the range specified and rise uniformly with kV.
- Perform the procedure for each selectable filter type.

Filter correction - 2mm Al

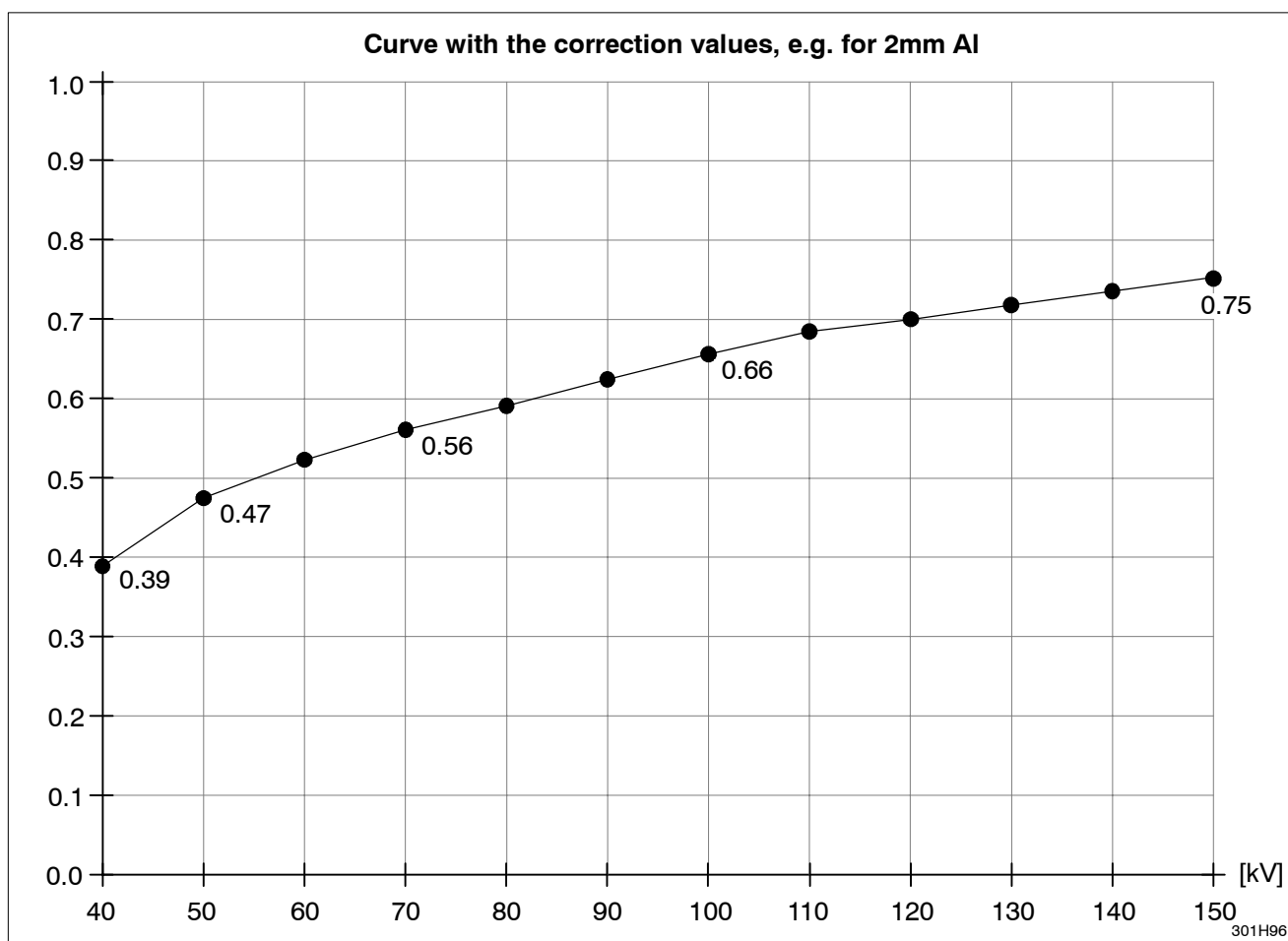
kV-checkpoint [kV]	50	70	100	150
default factor	0.47	0.56	0.66	0.75
measured dose [μ Gy] with filter				
measured dose [μ Gy] without filter				
new factor	new factor = dose with filter / dose without filter			

Filter correction - 1mm Al + 0.1mm Cu

kV-checkpoint [kV]	50	70	100	150
default factor	0.25	0.37	0.50	0.65
measured dose [μ Gy] with filter				
measured dose [μ Gy] without filter				
new factor	new factor = dose with filter / dose without filter			

Filter correction - 1mm Al + 0.2mm Cu

kV-checkpoint [kV]	50	70	100	150
default factor	0.123	0.230	0.370	0.53
measured dose [μ Gy] with filter				
measured dose [μ Gy] without filter				
new factor	new factor = dose with filter / dose without filter			



- Read out the default values of the filter tables for each kV checkpoint, correct with the factor determined and write back into the generator with <Transmit>.

Select menu:

ADJUST/ AREA EXPOSURE PRODUCT/ ADD FILTER CORRECTION TABLES/ ...

... **2mm AL**

... **1mm AL + 0.1mm CU**

... **1mm AL + 0.2mm CU**

- Save the specific correction tables with the SAVE function of XRGSCOPE <F3> key on the backup disk.

Recommended file names:

act_2al.tdl filter 2mm Al

act_01cu.tdl - filter 1mm Al + 0.1mm Cu

act_02cu.tdl filter 1mm Al + 0.2mm Cu

2. Alignment of “Function Unit kV”

2.1. General information

The actual value of the set kV must be attained at least after 2ms. At kV rise phase there must be neither kV break-in nor a kV overshoot.

The Factor Duty Cycle is based on an adapted tube and determines at local mains voltage and mains resistance conditions:

- the kV rise phase
- and
- the kV behavior during the exposure in falling load technique

as it takes into account the tolerances of the following FRUs (**F**ield **R**eplaceable **U**nits):

- | | | | |
|--------------------------------------|------------------------------------|----------------|----|
| 1. PCB EZ 130 | | | ** |
| kV_control_3 = 50kW | 1 converter | 4512 108 0908x | |
| kV_control_4 = 65/80kW | 2 converters | 4512 108 0910x | |
| | | | |
| 2. A complete power converter unit Q | | | ** |
| kV_power PCB(s) Q100 | (part of the power converter unit) | | |
| IGBT transistors | (part of the power converter unit) | | |
| | | | |
| 3. Resonance capacitors | (part of the power converter unit) | | ** |
| | | | |
| 4. High tension transformer | | | ** |

An exchange of one of the ** marked parts requires a realignment of the Factor Duty Cycle.

The Factor Duty Cycle is stored in the memory of PCB CU EZ139. If the CU has to be replaced the CU complete backup can be reloaded (with the actual factor) to the NVRAM memory or the Factor Duty Cycle must be re-aligned. Refer to figure 1:

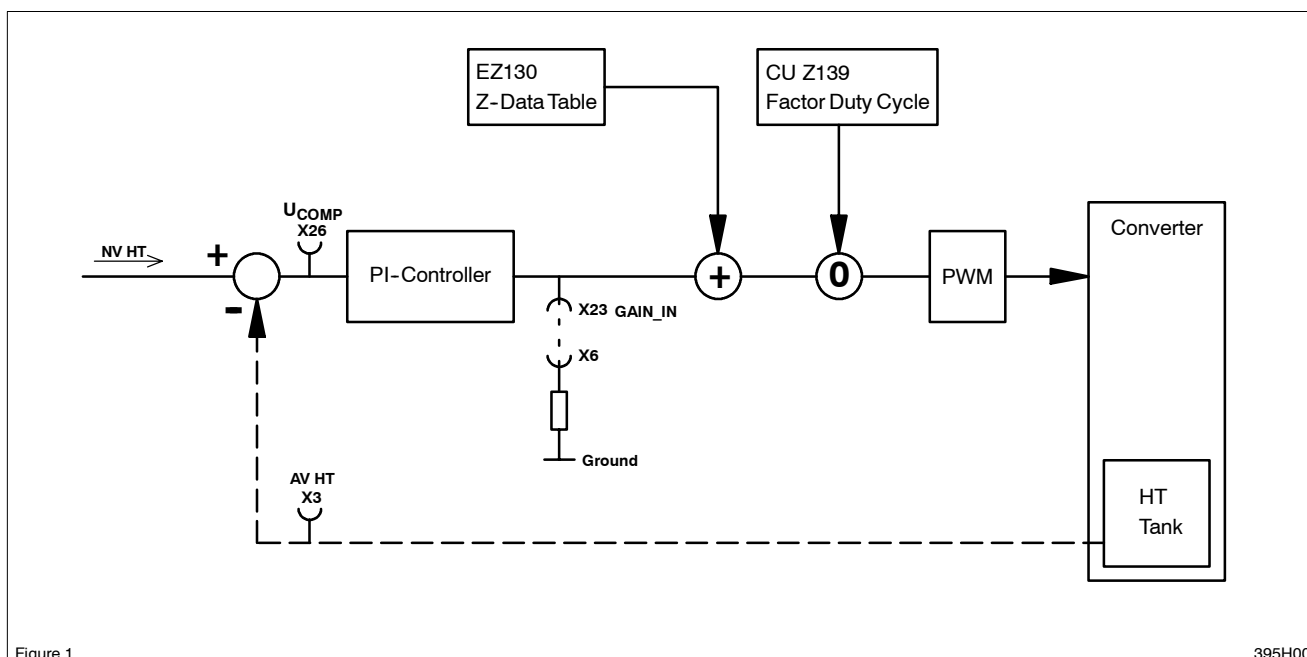


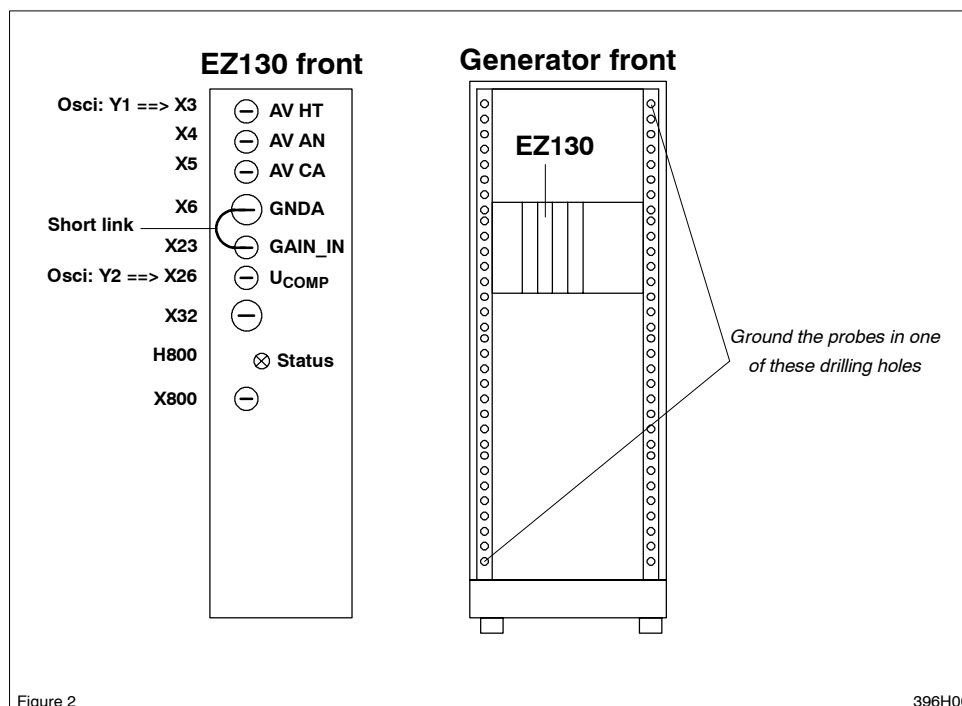
Figure 1

395H00

During alignment this Factor Duty Cycle must be entered via XRGSCOPE. The influence of this factor as a correction value for the Z-Data Table is monitored as the U_{COMP} signal, since the PI-Controller is deactivated by the grounded $GAIN_IN$ signal.

2.2. Connecting and setting the scope

For connections see figure 2:



Channel 1 = EZ130 X3 ----> AV HT ----> 20kV/V ----> 1V/div --> Zero-line at bottom of screen
 Probe GND = one of the drilling holes at the front cabinet chassis

Channel 2 = EZ130 X26 ----> U_{COMP} ----> 1V/div ----> Zero-line 2 div from bottom of screen
 Probe GND = one of the drilling holes at the front cabinet chassis

Trigger = external (preferred) ----> CTRL_X_C/ ----> backpanel EZX74 / negative slope
 or = internal channel 1 ----> AV HT ----> EZ130 X3 / positive slope at +3V
 Probe GND = one of the drilling holes at the front cabinet chassis

Time base = 5 or 10ms/div ----> trigger delay -1div

Note

A digital scope should not have any other ground connection than the ground of the 3 probes at the drilling holes at the front generator chassis.

A mains-driven scope must be isolated from earth potential, otherwise it might display artefacts.

2.3. Deactivating the kV controller

- Connect EZ130 X23 *GAIN_IN* and X6 *GNDA* with a short link (use a short wire).

Caution!

This alignment requires exposures with high kV.

Be sure the tube has been warmed up before.

2.4. Setting of exposure data

a) Set 141kV in case of

- 65/80kW
- the tube limit (of at least one tube) is 150kV perform this adjustment at the tube which has the highest kV limit programmed.

b) Set 125kV in case of

- 50kW
- and
- 65/80kW if the programmed application limit of the tube limit is 125kV.

Note

Any tube arcing during this adjustment requires the execution of the tube conditioning next as described in section 2 "INSTALLATION".

Disconnect the short link between X23 and X6.

Start over this adjustment from chapter 2.3 onwards if the tube conditioning was successful.

- Set kV and mA values according to the programmed tube limits:

a) 141kV: 200mA at kV_4 (65/80kW)

b) 125kV: 100mA at kV_3 (50kW)
 200mA at kV_4 (65/80kW)

- Set exposure time: 40ms

2.5. Adjustment of the "factor for duty cycle"

- Adjust the Factor Duty Cycle via service software XRGSCOPE by measuring U_{COMP} with the scope.
- Connect the service PC and start XRGSCOPE:
XRGSCOPE
SELECT UNIT ---> FU-kV ---> ADJUST ---> IGBT Pulse Width Correction ---> Factor Duty Cycle
- Set the starting value Factor Duty Cycle to **1.00**:

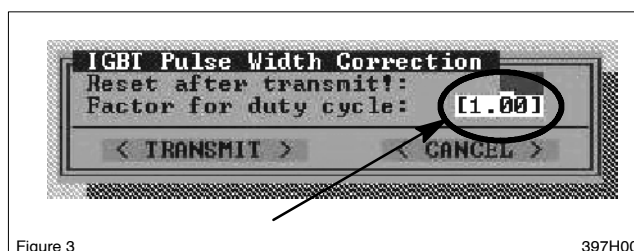
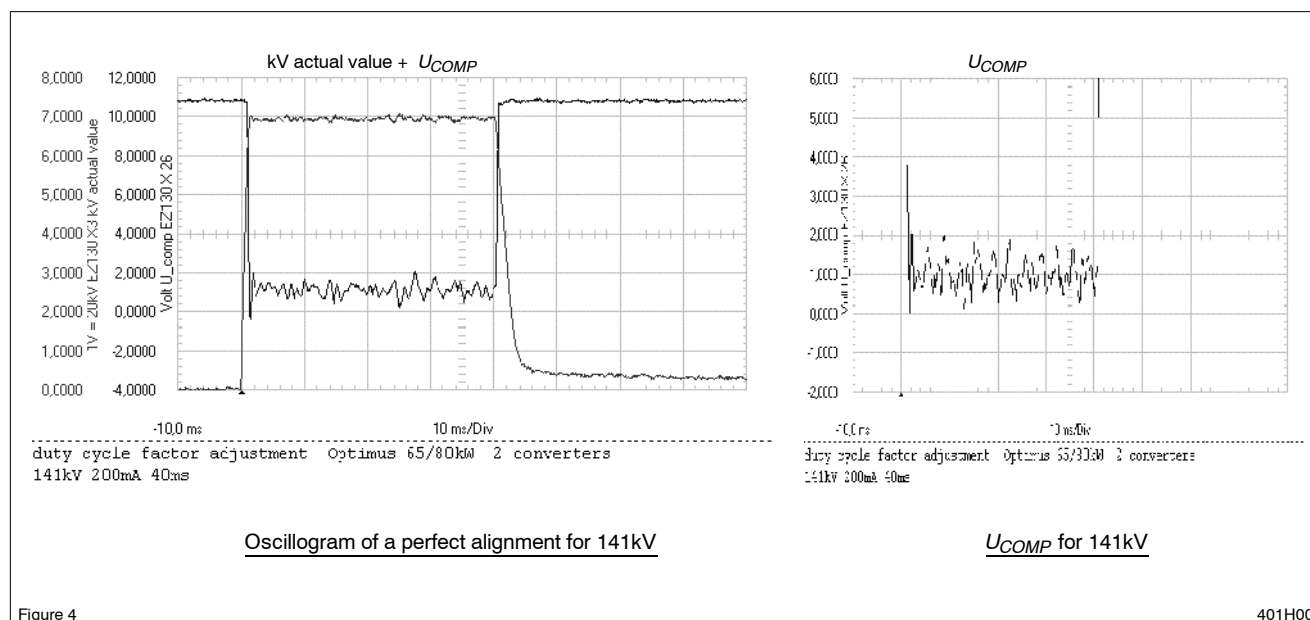


Figure 3

397H00

- If the U_{COMP} value does not match the requirements type in another Factor Duty Cycle value, <TRANSMIT> the screen and push the active RGDV button to get the new value validated.
- Switch an exposure.
The values are measured in the stationary condition. The transient behavior at the beginning of the exposure is not taken into account.

Result: In standby the U_{COMP} value is at about +11V, during exposure the mean value U_{COMP} must be as given in table 1 or 2, refer to figure 4:



Oscillogram of a perfect alignment for 141kV

 U_{COMP} for 141kV

Figure 4

401H00

a) 141kV setting (65/80kW only)

- Read the mean value of U_{COMP} for 141kV (see scope figure 4 or 5), correct the Factor Duty Cycle till U_{COMP} meets the required reference of +1V.

kV setpoint	mA setpoint	PCB type	U_{COMP}	Tolerance	kV peak of AV HT	Factor Duty Cycle:	Date:
141kV	200mA	PCB kV_control 4:	+1V	±0.5V	138kV		

Table 1: Factor Duty Cycle, settings 141kV (150kV limit)

Example how to correct the Factor Duty Cycle:

PCB kV_control 4:

- If the mean value of U_{COMP} is:
 > +1.5V **increase** the Factor Duty Cycle in steps of 0.01
 < +0.5V **decrease** the Factor Duty Cycle in steps of 0.01
- Check also the kV peak value AV HT (not the overshoot), it must be **138kV** for **141kV** setpoint. (see scope figure 5)
- Remove short link EZ130 X23 GAIN_IN.
- Record the findings in table1.

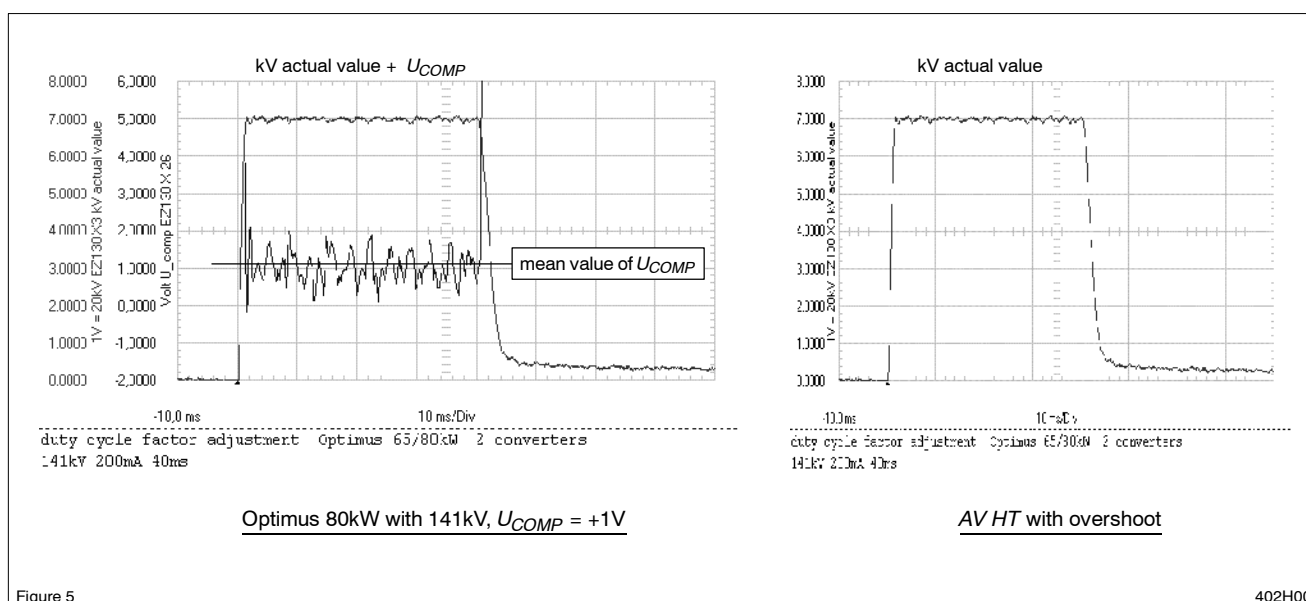


Figure 5

402H00

b) 125kV setting (50/65/80kW)

- Read the mean value of U_{COMP} for 125kV (in principle figure 4 or 5).
- Correct the Factor Duty Cycle till U_{COMP} meets the required reference of 0V.

kV setpoint	mA setpoint	PCB type	U_{COMP}	Tolerance	kV peak of AV HT	Factor Duty Cycle:	Date:
125kV	100mA	PCB kV_control 3:	+0V	+1V / -0,5V	125kV		
125kV	200mA	PCB kV_control 4:	+0V	±0.5V	125kV		

Table 2: Factor Duty Cycle, 125kV limit

Example how to correct the Factor Duty Cycle:

PCB kV_control 3:

- If the mean value of U_{COMP} is: $> +1V$ **increase** the Factor Duty Cycle in steps of 0.01
 $< -0.5V$ **decrease** the Factor Duty Cycle in steps of 0.01

PCB kV_control 4:

- If the mean value of U_{COMP} is: $> +0.5V$ **increase** the Factor Duty Cycle in steps of 0.01
 $< -0.5V$ **decrease** the Factor Duty Cycle in steps of 0.01
- Check also the kV peak value AV HT (not the overshoot), it must be **125kV** for **125kV** setpoint.
- Remove short link EZ130 X23 GAIN_IN.
- Record the findings in table 2.

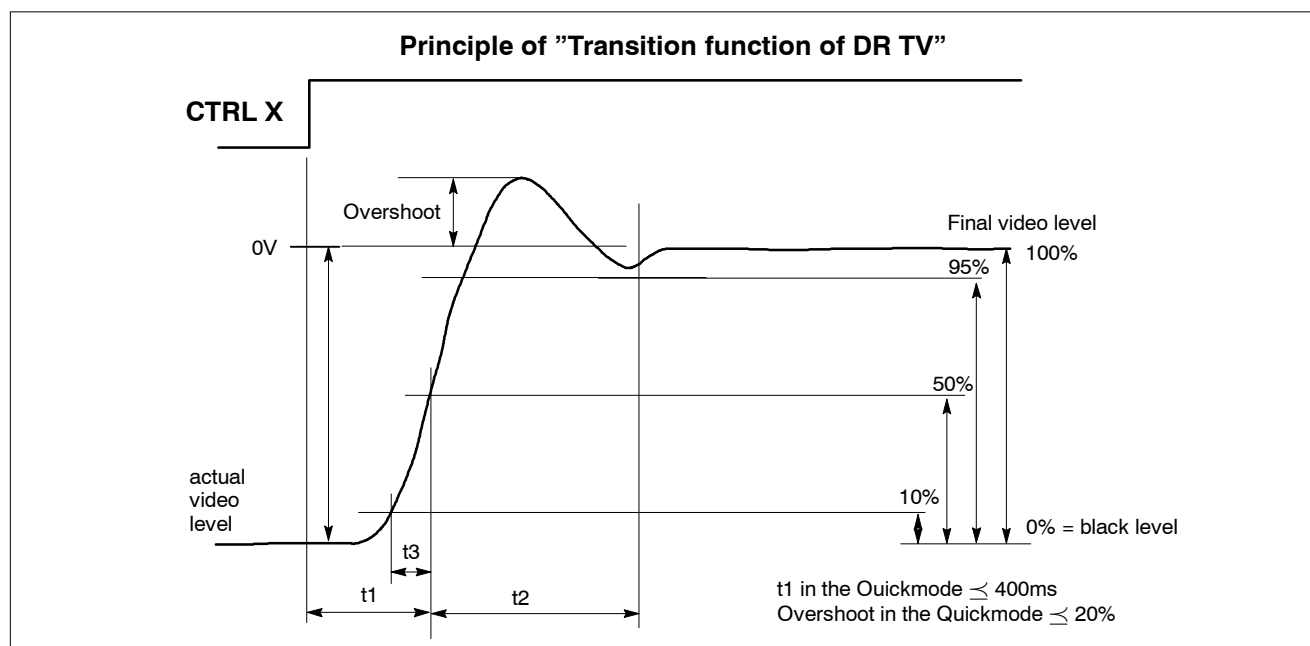
3. Dose rate alignment for continuous fluoroscopy when using the dose-rate signal DR TV (formerly ADC) // dose-rate control via TV-chain

3.1. Aim

The amplification factor of the control circuit must be adjusted such that

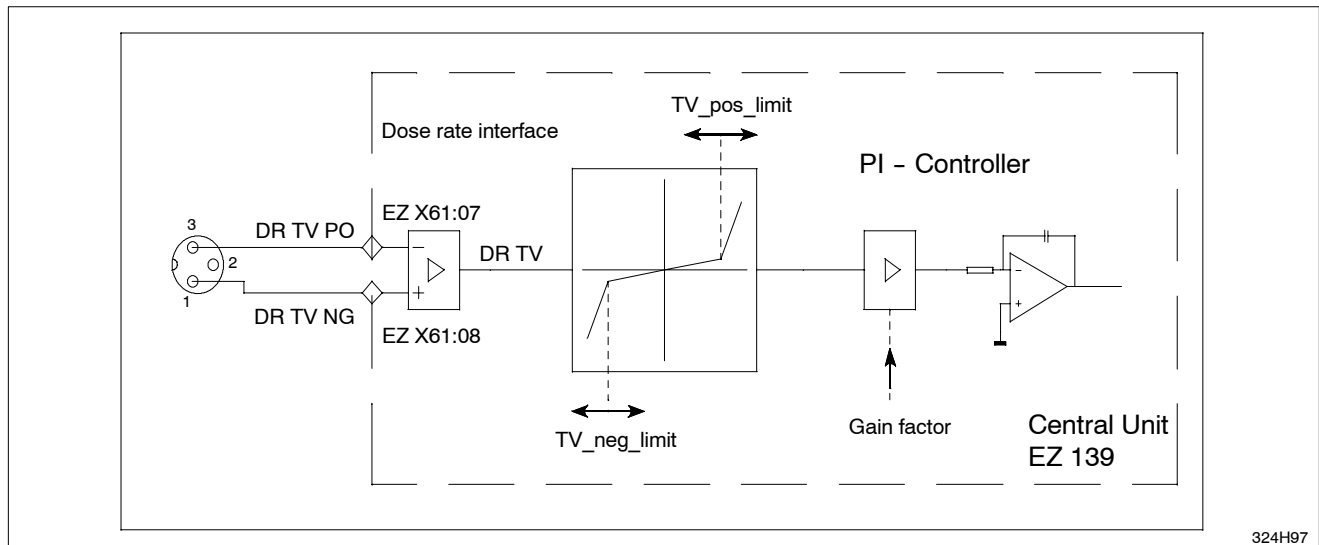
- the TV image becomes visible within about 400ms after fluoroscopy is switched ON with RQXGFL
- there is no flashing of the TV image (overshoot < 20%).

Also see sketch below:



3.2. Principle

Adjusting value : Transition function of DR TV
 Variables : TV_pos_limit / TV_neg_limit / Gain factor



- Set the gain factor to default value = 1.00 with FW XRGSCOPE:

OPTIMUS

--> Adjustments

--> Dose rate control

--> Amplification gain

--> CONT

Gain factor 0.5...2 (default = 1): [1.000]

- With fluoroscopy **switched OFF**, measure the black level of the dose-rate signal of the TV chain.
Suitable test points:
 - WN 25 DRDFP (with a TV chain XTV 11)
 - (EZ X61:7 = DR TV PO)

The kink of the characteristic curve TV_pos_limit to be adjusted must be:

TV_pos_limit = DR TV PO (black level measured) - 500mV

Example: DR TV PO = 7.3V → adjusting value TV_pos_limit = 6.8V

- Set TV_pos_limit via XRGSCOPE:

OPTIMUS

--> Program

--> Dose rate control

--> **CONT:**

Program settings for continuous fluoroscopy:

+ ----- CONT_MOD.TDL ----- +	
scantime_TV [ms]: [20.000]	→ 50Hz = 20ms
scantime_TV valid: Yes ☐	→ yes with control via TV chain. With photo diode = no.
P_max_EDL [W]: [250]	→ 250 default: Effective only when SID WB X12:1 DRLM is switched ON.
TV_pos_limit [V]: [6.8]	→ DR TV PO - 500mV. (TV black voltage - about 500mV)
TV_neg_limit [V]: [-6.8]	→ = - TV_pos_limit [V]

< OK >	

In case the switch ON procedure is fast enough with this setting

$T1 \leq 400\text{ms}$ in quick mode or $T1 \leq 500\text{ms}$ in normal mode

and the TV chain does not flash when fluoroscopy is switched ON,

overshoot $\leq 20\%$

the alignment with the oscilloscope described below is **not** required.

3.3. Alignment of DR TV with the oscilloscope

Settings of the oscilloscope:

Y1 to EZ 150 X6 : EN X C/ [10V/div]
 Y2 e.g. with XTV11
 to WN 25 : DRDFP [5V/div]
 Ground to EZ 150 X5 : GNDA
 Time base : 200ms/div
 Trigger : Y1 / - DC

The alignment should not be carried out in the quick mode since the differences of the transition functions are not big enough in the quick mode. However, in the normal mode the overshoot is slightly higher than 20%.

Since fluoroscopy is automatically in the quick mode for up to 30s after the end of fluoroscopy, after each oscillogram fluoroscopy must be switched OFF for at least 30s:

Pause > 30s → Fluoro ON → Oscillogram → Fluoro OFF
 → Pause > 30s → Fluoro ON → Oscillogram → Fluoro OFF
 → ...

Fluoroscopy adjustments for all oscillograms:

- Dark voltage of the TV chain measured: DR TV PO_{dark} = 7.3V

XRGSCOPE:

OPTIMUS

--> Program

--> Dose rate control

--> **CONT:**

scantime_TV [ms] : 20.000 (→ 50Hz)
 scantime_TV valid : Yes
 P_max_EDL [W] : 250

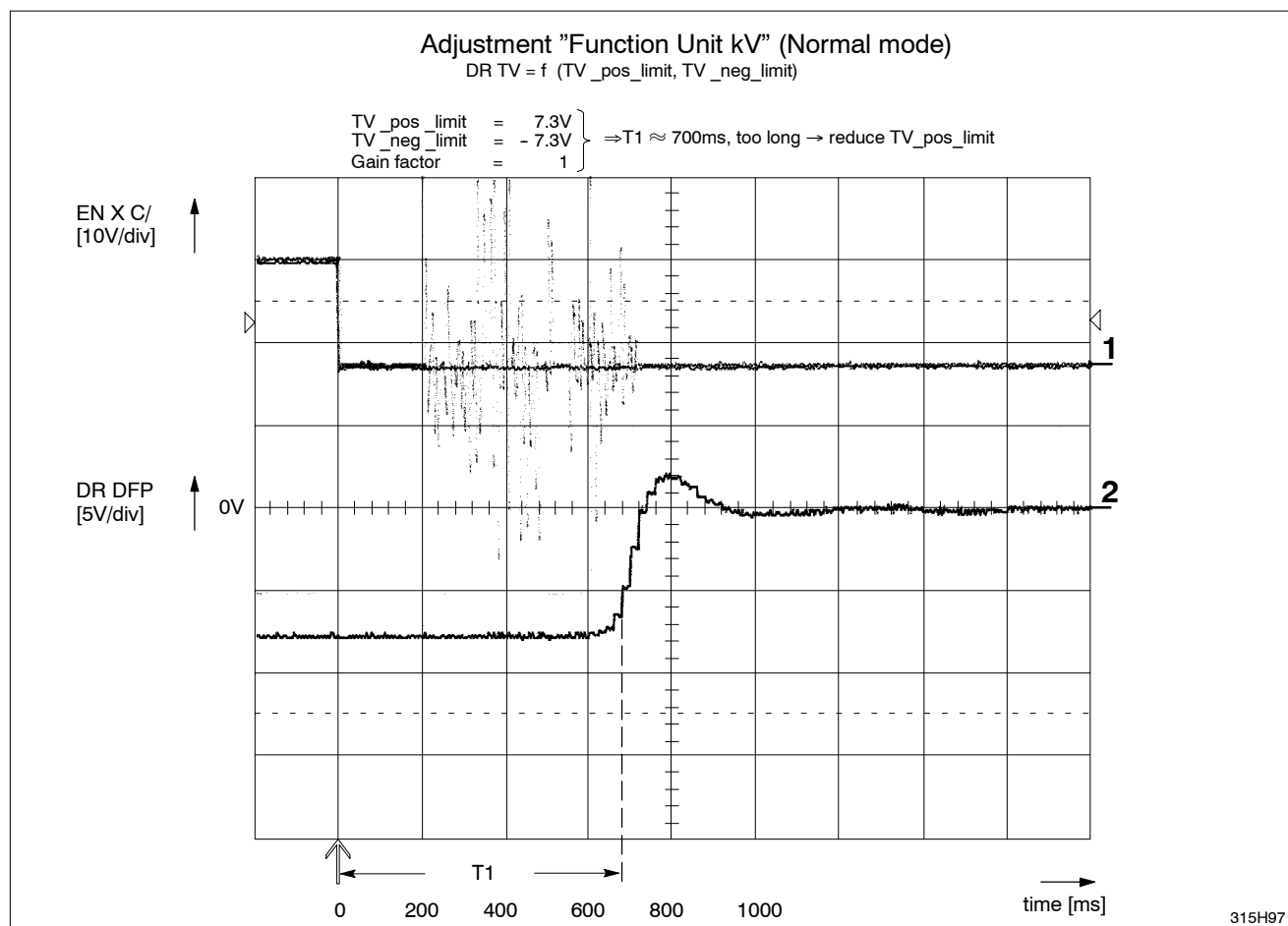
Operating point of fluoroscopy in the automatic mode (example XTV 11):

- 9" I.I. format
- Filter in the path of radiation: 1.5mmCu + 20mmAl ==> 74kV/ 2.2mA

First reference oscillogram:

Values adjusted with XRGSCOPE:

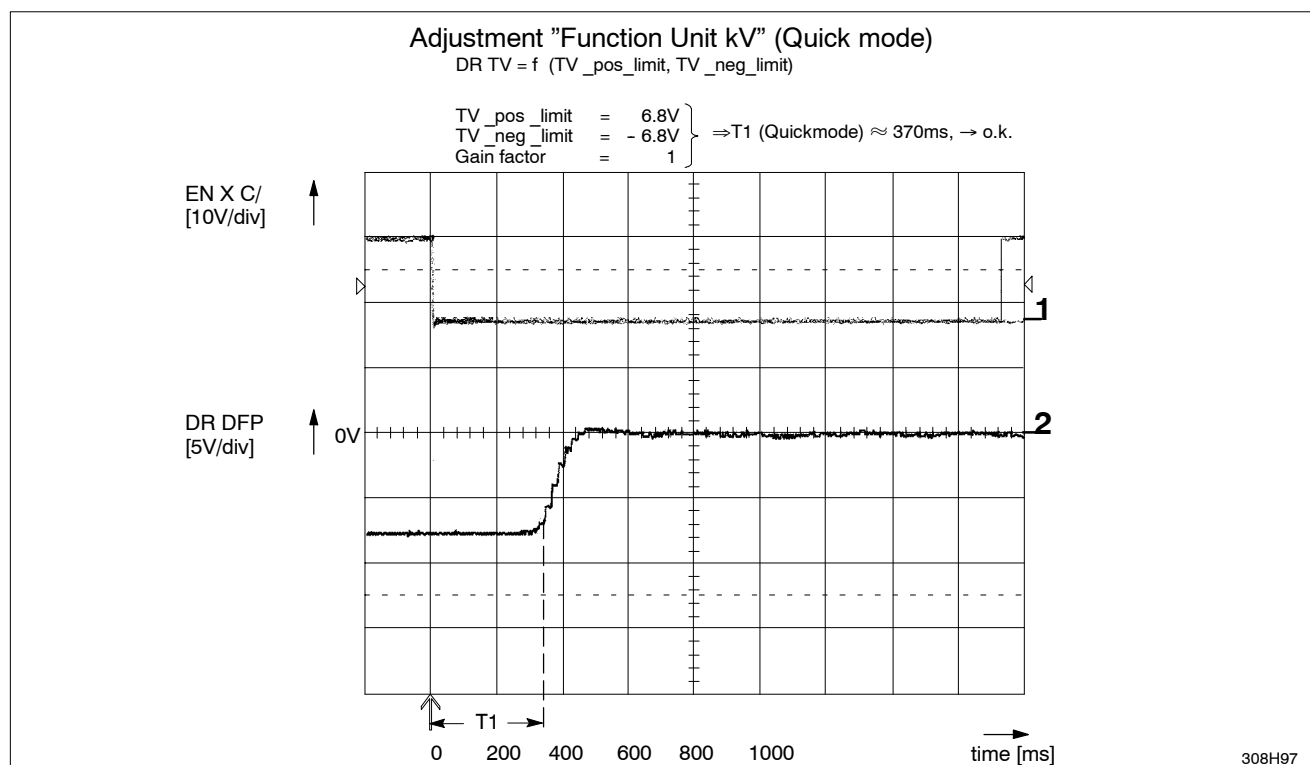
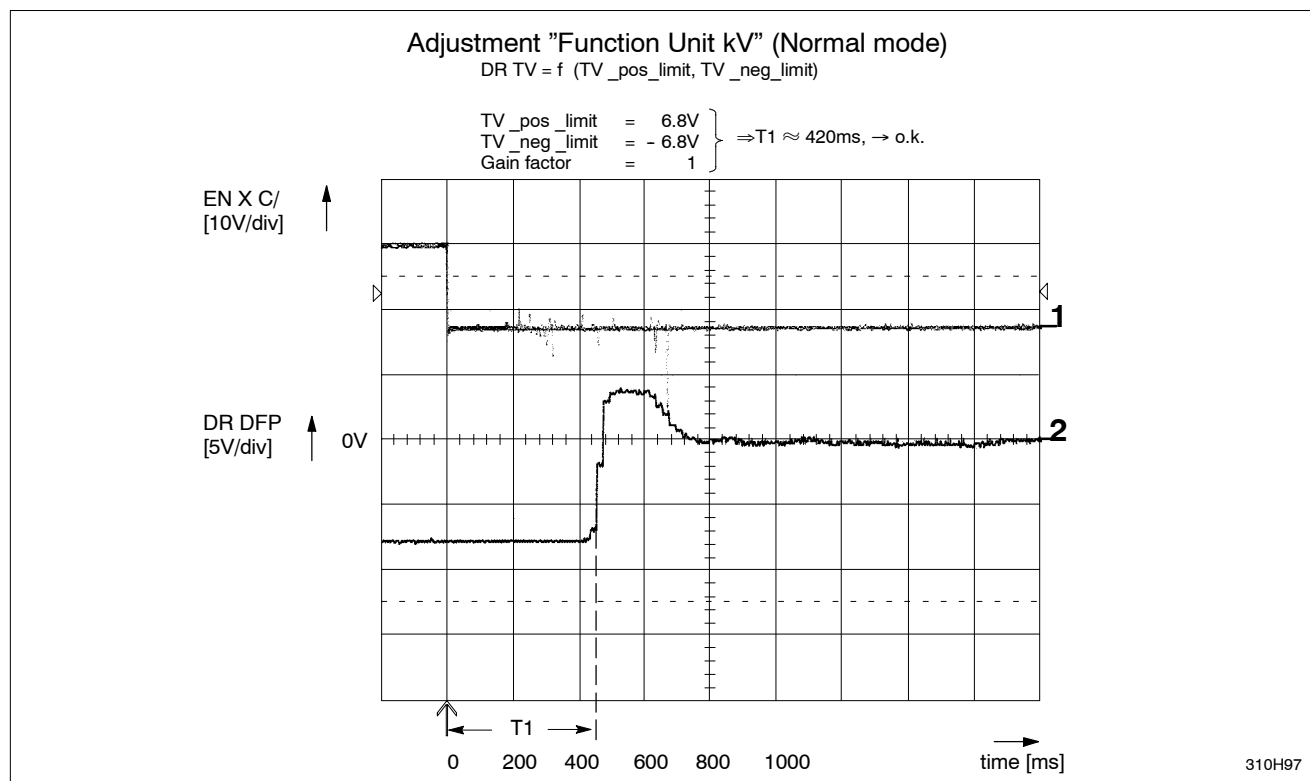
- TV_pos_limit [V]	: [7.3]	} ==> T1 ≈ 700ms --> too long --> reduce TV_pos_limit [V]
- TV_neg_limit [V]	: [-7.3]	
- Gain factor	: [1.00]	



Second reference oscillogram:

Values adjusted with XRGSCOPE:

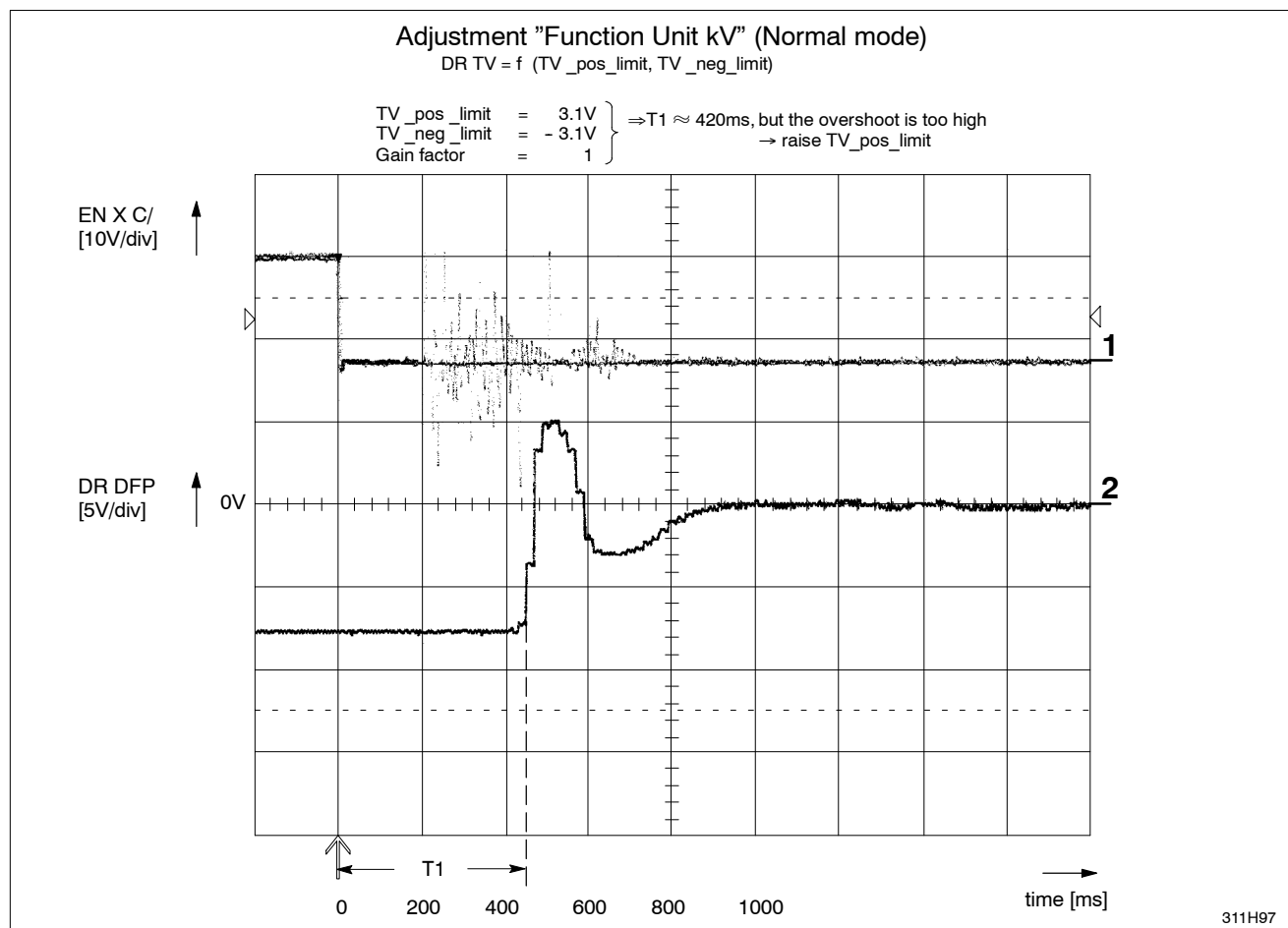
- TV_pos_limit [V]	: [6.8]	} ==> T1 $\approx$ 420ms --> o.k. and gain factor can remain as they are
- TV_neg_limit [V]	: [-6.8]	
- Gain factor	: [1.00]	



Third reference oscillogram:

Values adjusted with XRGSCOPE:

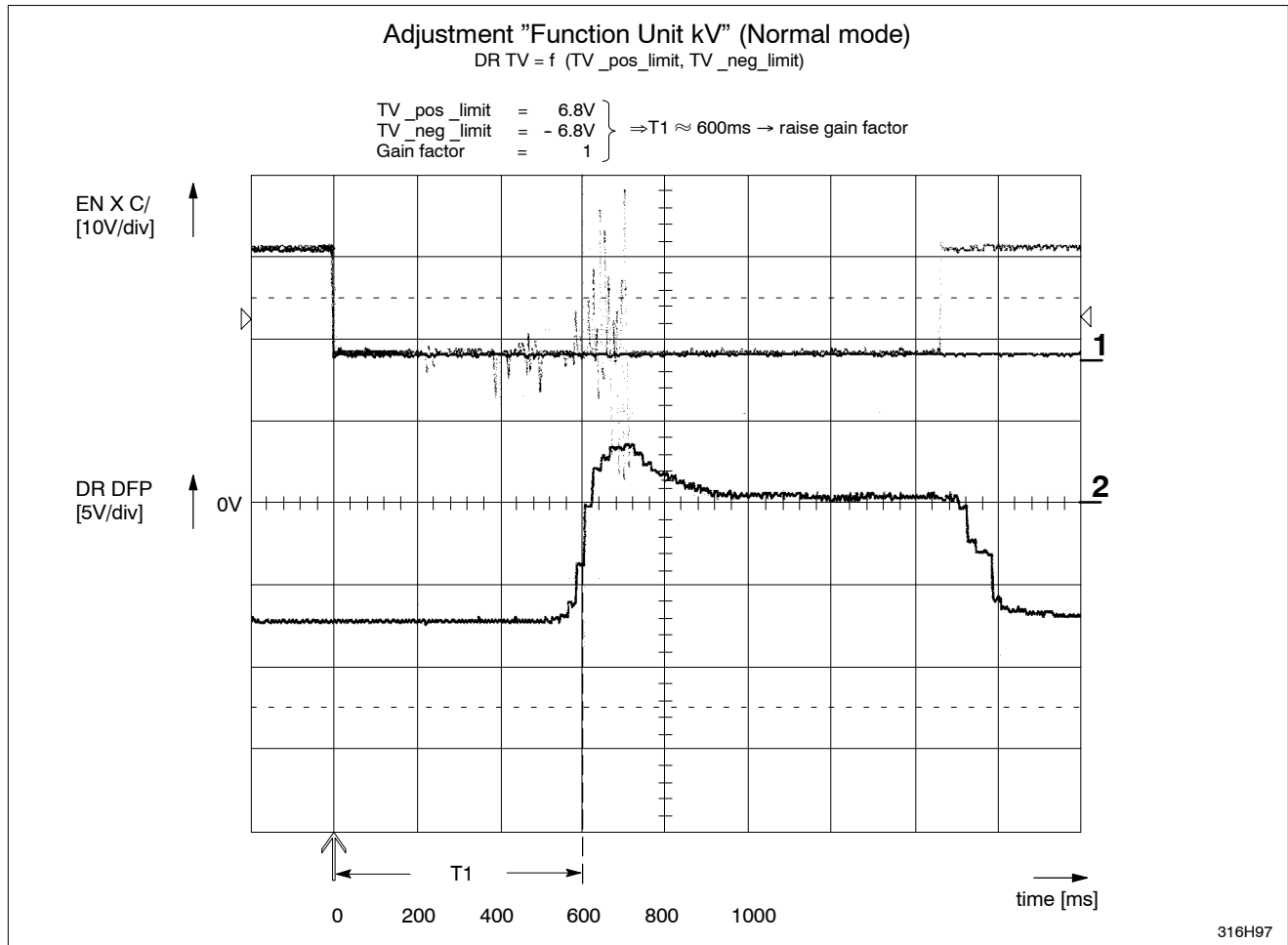
- TV_pos_limit [V] : [3.1]
 - TV_neg_limit [V] : [-3.1]
 - Gain factor : [1.00]
- } ==> T1 ≈ 420ms --> o.k., but the overshoot is too high
 The TV image flashes!
 --> Raise TV_pos_limit [V]



Forth reference oscillogram:

Values adjusted with XRGSCOPE:

- TV_pos_limit [V]	: [6.8]	} ==> T1 ≈ 600ms --> too long --> Raise gain factor to 1.00!
- TV_neg_limit [V]	: [-6.8]	
- Gain factor	: [0.50]	



4. Maximum patient entrance dose rate: Entrance Dose rate Limiter (EDL)

4.1. Aim

In some countries the maximum patient entrance dose rate must be limited to comply with the respective national regulations, for instance 10R/min = 1.4567 μ Gy/s in the USA.

4.2. Principle

The maximum patient entrance dose is measured with maximum kV. By reducing the maximum power P_max_EDL provided by the generator, the dose rate is reduced until it complies with the national regulations or the individual wish of the user.

Note

The dose rate reduction programmed via P_max_EDL is effective only when the SID contact (Source Image Distance) is switched ON: WB X12:1 DRLM $\rightarrow$ closed!

4.3. Alignment

- Cover the I.I. with lead such that with fluoroscopy maximum kV (110kV) are adjusted (protection of the I.I. against excessive radiation).
- Adjust the exam./aux. unit in such a way that the SID contact is closed.
If necessary, place a shorting plug on decade: WB X12:1 <----> X12:10 (ground).
- Adjust the exam./aux. unit in such a way that the smallest distance between tube and patient is effective.
- Position the dose rate measuring chamber in such a way that it is at the same height where the radiation would enter the patient.
- Switch ON fluoroscopy.
- Reduce/raise **P_max_EDL [W]** with the service software XRGSCOPE until the dose rate is identical with the maximum permissible value:

XRGSCOPE OPTIMUS

--> Program

--> Dose rate control

--> **CONT:**

```
+ ----- CONT_MOD.TDL ----- +
| scantime_TV [ms]:    [ 20.000] |
| scantime_TV valid:      Yes    |
|
| P_max_EDL [W]:      [  nnn]   |
|
| TV_pos_limit [V]:     [ 6.8]   |
|
| TV_neg_limit [V]:     [-6.8]   |
| -----|
|    < OK >    |
| -----|
```

Range: 0 ... 9000W (250 default)

$\rightarrow$ Effective only when SID contact WB X12:1 DRLM is switched ON.

- Note the measuring values:

P_max_EDL: [W]														
Dose rate: [μGy/s]														

Example of a measuring setup:

